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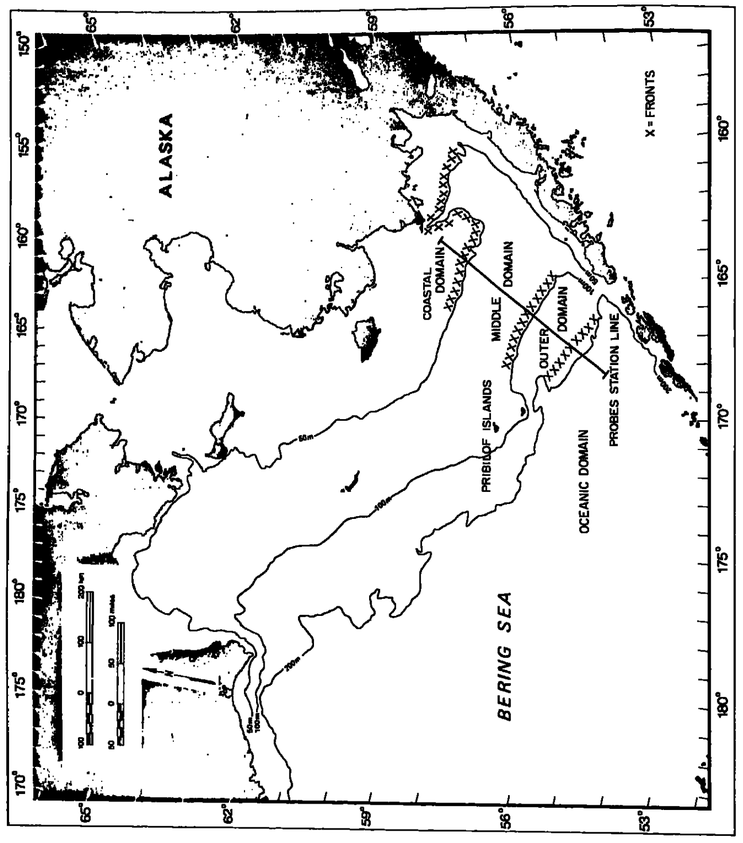

The Oceanography Report—pages 730–732

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION VOL. 62, NO. 44, PAGES 729-736 NOVEMBER 3, 1981

Particles and Fields—Ionosphere

5535 Interactions between waves and particles
A UHF CROSS-MODULATION D-REGION HEATING EXPERIMENT WITH ATMOSPHERIC IMPLICATIONS
M.P. Sulzer (National Astronomy and Ionosphere Center, Arecibo Observatory, Box 995, Arecibo, Puerto Rico 00613) J.D. Mathews and K. A. Tapia

A unique wave interaction experiment employing the Arecibo 2.0 megawatt 430 MHz radar as disturbing or heating transmitter has been performed. The purpose of this experiment was to evaluate UHF electron heating effects and to extend the wave interaction technique to higher than usual frequencies (100 MHz). The heater beam used was much smaller in angular extent than the possibly of wanted beam yielding an unfavorable geometric weighting factor and making the experiment very sensitive to reflection properties of the E region. Nonetheless wave interaction was easily detected using a completely digital signal processing technique. Comparison of experimental wave interaction results with a numerical model of the process indicates that lower thermosphere electron cooling rates are possibly too small by a factor of four. Power spectra of the 3.155 MHz monitor signal (reflected from E region) amplitude fluctuations for "quiet" and "disturbed" days are also given. (UHF wave interaction, electron heating, electron cooling)

5540 Particle Precipitation
THE SIGNIFICANCE OF VLF TRANSMITTERS IN THE PRECIPITATION OF INNER BELT ELECTRONS
W. L. Imhof (Space Sciences Laboratory, Lockheed Palo Alto Research Laboratory, 3251 Hanover Street, Building 255, Palo Alto, California 94304), R. R. Anderson (Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242), J. B. Reagan and E. E. Gaines (Lockheed Palo Alto Research Laboratory, Palo Alto, California 94304)

From the low altitude satellite P78-1, narrow and sometimes multiple peaks have been observed in the energy spectra of electrons 60 to 1120 keV precipitating in the drift loss cone from the inner radiation belt. Simultaneously measurements of the plasma wave environment at higher altitudes on the same field lines have been made with the IMEE plasma wave experiment in many cases. The peaks in electron energy are sometimes extremely narrow, being of the order of 20 keV wide after the instrument resolution is unfolded. The plasma wave observations in these cases reveal the frequent presence of single and sometimes multiple monochromatic frequencies in the 10 kHz to 25 kHz range which are attributed to ground-based VLF transmitters. The plasma wave experiment also provides electron plasma density profiles. The variations of the peak energies with L value and the nearly simultaneous and spatially coordinated narrow-band wave frequencies strongly support the conclusion that the narrow peaks in the electron spectra result from cyclotron resonance interactions with the waves produced by ground-based VLF transmitters and that the effects of two or more transmitters are sometimes observed simultaneously.
J. Geophys. Res., Blue, Paper 2A1401

5563 Plasma motion, convection, or circulation
TITAN'S ION ENVIRONMENT OBSERVED FROM VOYAGER 1
S. M. Krimigis (NASA/Goddard Space Flight Center, Laboratory for Planetary Atmospheres, Greenbelt, MD 20771), T. P. Armstrong, W. I. Axford, C. O. Bostrom, J. A. Van Allen, J. F. McDonald, L. J. Lanzerotti, and S. M. Krimigis

Electron and ion measurements made by the Voyager 1 plasma science instrument revealed a plasma wake surrounding Titan in Saturn's rotating magnetosphere. This wake is characterized by a plasma that is more dense and cooler than the surrounding subsonic magnetospheric plasma. The density enhancement is produced by the deflection of magnetospheric plasma around Titan and the addition of exospheric ions picked up by the rotating magnetosphere. By using simple models for ion pickup in the ion exosphere outside Titan's magnetic tail and ion flow within the boundaries of the tail, the interaction between Saturn's rotating magnetosphere and Titan is shown to resemble the interaction between the solar wind and Venus. Outside the magnetic tail of Titan, pickup of H^+ formed by ionization of the H exosphere is indicated when synthetic and observed ion spectra are matched. Close to the boundary of the tail, a reduction in plasma flow speed is found, providing evidence for mass loading by the addition of N_2^+/HCN^+ and H^+ to the flowing plasma. The boundary of the tail is indicated by a sharp reduction in the flux of high energy electrons, which are removed by inelastic scattering with the atmosphere and centrifugal drift produced when the electrons encounter the magnetic field draped around Titan. Within the tail the plasma is structured as the result of spatial and/or temporal variations. The ion mass cannot be determined uniquely in the tail; however, mass measurement suggests the presence of a heavy ion with a mass of order 28 amu: One candidate is HCN^+, suggested as the dominant topside ion of the ionosphere, which may flow from the ionosphere into the tail. (Ion exosphere, ion pickup, plasma measurements).
J. Geophys. Res., Blue, Paper 1A1504

5563 Plasma motion, convection, or circulation
ION-NEUTRAL MOMENTUM COUPLING NEAR DISCRETE HIGH-LATITUDE IONOSPHERIC FEATURES
J.-P. St-Maurice and R.W. Schunk (Center for Atmospheric and Space Sciences, Utah State University, Logan, Utah 84322)

We have developed a two-dimensional numerical model to study momentum coupling between the ionosphere and neutral atmosphere in the vicinity of discrete high-latitude features, such as convection channels and plasma density troughs. The model, which is based on generalized magnetohydrodynamic equations, takes account of global pressure gradients, viscous dissipation, ion drag, the Coriolis force, and electrodynamic drifts. From our initial steady state investigation, we have found the following: (1) In convection channels, significant shears and rotations of the thermospheric flow can occur below 200 km if a minimum in the electron density profile is present between the E and F regions. (2) In convection channels, the thermospheric wind decreases with height in the F-region owing to the effects of horizontal viscosity; (3) At low altitudes, the boundaries of convection channels may produce Ekman spirals; (4) A convection channel acts to induce a thermospheric motion over a region that extends up to 1000 km on both sides of the convection channel owing to the effects of horizontal viscosity; (5) In general, thermospheric winds driven by large-scale pressure gradients have an appreciable effect on the thermospheric flow in and near convection channels; (6) Narrow channels of rapidly convecting, low density plasma produce a small thermospheric response; and (7) Joule heating is generally the dominant heat source inside convection channels, while viscous heating dominates outside. Frequently, however, viscous heating can be the dominant heat source both inside and outside of convection channels.
J. Geophys. Res., Blue, Paper 1A1378

5580 Wave propagation
DEPOLARIZATION OF VHF GEOSTATIONARY SATELLITE SIGNALS NEAR THE EQUATORIAL ANOMALY CREST8
N.C. Lee (Regis College Research Center, Weston, Massachusetts 02193), A. DasGupta, J.A. Klobuchar, S. Basu and S. Basu

The nighttime polarization fluctuations of linearly polarized 136 MHz satellite signals received at Ascension Island located near the southern crest of the equatorial anomaly have been shown to be the manifestation of depolarization effect due to the diffractive scattering by small-scale (<200 m) density irregularities with power-law spectra. The theory can explain the coexistence with L-band scintillation. The absence of this phenomenon at equatorial locations off the anomaly crests is attributed to two factors : (1) the ambient plasma densities are relatively low and (2) the propagation angles of satellite signals are nearly perpendicular to the geomagnetic field. (Depolarization, equatorial anomaly, irregularities, L-band scintillation).
Rad. Sci., Paper 1S1430

5565 X rays, gamma rays, and cosmic rays
HEAO 3 MEASUREMENTS OF THE ATMOSPHERIC POSITRON ANNIHILATION LINE
V. A. Nakonov (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, U.S.A.) J. C. Ling and A. S. Jacobson

All spectra obtained with the High Energy Resolution Gamma-Ray Spectroscopy Experiment (HEAO C-1) on the third High Energy Astronomy Observatory (HEAO 3) contain a strong line at 511 keV resulting from positron annihilation. This line originates in the instrument itself, the earth's atmosphere and cosmic sources, possibly including the diffuse cosmic background. In order to understand the emission from cosmic sources, the atmospheric positron annihilation line emission has been determined as a function of geomagnetic latitude and zenith angle. As expected the intensity of the line increases with increasing latitude, it was found that variations with zenith angle can be satisfactorily explained only if the atmospheric emission exhibits significant limb darkening. The atmospheric line has an energy of 511.07 ± 0.10 keV and a net width of 2.29 ± 0.30 keV FWHM. Characterization of the instrument background have allowed an upper limit of 9.4×10^{-3} photons/cm²-sec-sr to be placed on any narrow (≤ 3 keV) diffuse cosmic emission at 511 keV.
J. Geophys. Res., Blue, Paper 1A139b

5599 General or miscellaneous
NUMERICAL SIMULATIONS OF A RADIALLY INJECTED BARIUM CLOUD
Daniel J. Swift (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701) Eugene H. Wescott

Electrostatic two-dimensional numerical simulations of a radially symmetric barium injection experiment show that ions created by solar UV ionization are electrostatically bound to the electrons which remain tied to the field lines on which they are created. Two possible instabilities are identified but neither of them causes the barium plasma cloud to polarize in a way that would allow the plasma to keep up with the neutrals. In a second model the velocity of the neutrals was allowed to be an azimuthal function of velocity. In this case a portion of the cloud did polarize in a way that allowed a portion of the plasma to detach and move outward. An approximate speed of the generic "E" x "B" rapid detachment was found when only the density of the neutrals was given an azimuthal asymmetry.
J. Geophys. Res., Blue, Paper 1A1452

Editorial

Instrumentation Crisis for VGP

The status of geochemical/mineralogical instrumentation is a matter of great concern. Not only is much of the present equipment obsolete and poorly maintained because of lack of technical staff and money, there is also great concern about the pressing demands of new instruments (e.g., synchrotrons, ion microprobes, high-energy mass spectrometers). Problems concerning instrumentation pervade the entire field of science, and they are particularly severe because of the cuts in the overall government budgets. These problems are recognized by the National Research Council (NRC) and the General Accounting Office and are the subject of several studies. The pressures on the Earth Sciences Division of the National Science Foundation have been pointed out by its director, Robin Brett, and there is extreme concern at the moment about the science budgets as opposed to the engineering budgets of NASA.

To study the status of geochemical/mineralogical instrumentation, an ad hoc committee of the Geological Sciences Board (GSB) of the NRC has been appointed by GSB chairman, William R. Dickinson. The members of this committee are cochairmen William W. Hay and William C. Luth; Gerald V. Gibbs, Joseph V. Smith, George R. Tilton, and W. Gary Ernst. Dickinson proposed the following questions:

1. What, in fact, is the state of instrumentation nationally, i.e., is total inventory adequate and is it being used effectively?
2. What can be done within the framework of foreseeable federal budgetary constraints to alleviate shortages that exist?
3. What is industry's potential role in addressing the overall funding problem?
4. Are there new creative or alternative methods for financing (i.e., in acquisition, maintenance, upgrading, replacements, etc.) that might exploit available resources more satisfactorily?
5. Is there a conceivable role for identified regional research centers or shared arrangements that offer advantages so far unexplored?

Other questions will be addressed when they have been properly identified.

The first meeting of the ad hoc committee was held at Cincinnati during the GSA Meeting. The second meeting will be held in San Francisco during the AGU Meeting, and an open informal session will also be held during the AGU meeting. The report of the ad hoc committee must be completed by March 1982.

My own views, which are tentative, can be discussed under two major headings.

The Need for More Funding

Geochemical instrumentation is severely underfunded in relation to some other areas of scientific instrumentation. This is partly the result of the relatively simple instruments used in geochemistry up until the last 20 years. Whereas nuclear and particle physicists were already using expensive generators some 40 years ago and had developed large teams of engineers and scientists over the following 20 years, most geochemists, even today, work in small independent laboratories that are poorly equipped with technical staff and facilities. Only some are fortunate enough to work in institutions with access to first-class technical services. The problems become increasingly severe as certain instruments (X ray diffractometers and electron microprobes and microscopes, for example) become absolutely fundamental to both research and teaching programs, while other instruments are being developed (e.g., pulsed neutron generators, X ray and ultraviolet light sources, high-energy mass spectrometers). If overall funding is to stay level, or even to decline, I can see no way that all desirable goals can be achieved. Hence our long-term primary goal is to find out whether the total funding can be increased in the face of intense competition. Ultimately, this becomes a political and sociological question from which a wide range of views can be expected. No doubt some of you will speculate on the relative cost of scientific research and other human endeavors; in particular, expenditures on war and defense and on various drugs might be discussed.

In the short-term (approximately 5 years), it seems likely that federal and state funds will prove to be strictly limited. In theory, tax reductions for both individuals and corporations should lead to a greater amount of disposable income. In practice, gifts of either money or equipment will probably prove to be erratic unless a national sense of urgency translates into a major campaign of systematic donations. The Petroleum Research Fund of the American Chemical Society has been very efficient in dispensing research grants from industrial funds. Should an industry-wide effort to disburse funds for research facilities and instruments be organized in geochemistry? It seems totally impractical to organize gifts from individuals, and efforts by individual institutions should prove more profitable. But to be successful, there must be a recognition by wealthy potential donors that scientific research, in general, and geochemistry, in particular, needs a lot of help. Is it realistic to expect an individual to donate a half million dollars for a new electron microprobe at his or her alma mater, especially when university administrators are trying to raise money for faculty salaries and buildings?

The Need for Improved Efficiency

Whatever the chances of increased funding, it is imperative to find ways of using present equipment with greater efficiency. Probably some distinction must be made between 'frontier instruments' and 'basic instruments.'

About the only way to save substantial amounts of money on new expensive instruments that open up new frontiers is to limit the number. This automatically leads to establishment of 'research centers.' I maintain that it is false economy to starve such a research center. Each one should be enabled to compete on a worldwide level; in particular, it should be staffed by first-rate people paid on, at least, a semipermanent basis instead of on the more common catch-as-catch-can basis. It may be possible to save some money by joint development of instruments with scientists in other countries. This has the additional psychological benefit of forging international friendships in this era of dangerous nationalistic feuds. However, it is a nuisance, at best, and a downright pain, at worst, for an outsider to work at a research center, even if the staff goes out of his way to welcome and help visitors. To minimize these problems, locations should be chosen to ease travel. Commuting by car, bus, or train is cheaper and generally easier than overnight stays after long flights; furthermore there is less dislocation of teaching and family life. There are many grave disadvantages to 'research centers,' and I am sure that there will be considerable feeling against them. Hence, it is important to minimize the need.

Turning to 'basic instruments,' there is much that can be done. First, it is necessary to encourage manufacturers to avoid unnecessary 'bells and whistles.' After some years of development, there is a danger that a basic instrument becomes loaded with unnecessary frills. I believe that new electron microprobes are becoming too complex and too expensive. Who needs a servo-operated sample chamber powered by air compressors? Who needs an SEM facility on an electron microprobe used mainly for analyses on grains at least 10 μm across? Let us urge construction of basic instruments whenever possible. Two instruments at $250,000 can be better used than one at $500,000. Second, existing instruments must be kept in service for a longer period. Of course, it is nice to boast about the latest shiny paint, but perhaps we should boast instead about the Puritan virtue of make-do-and-mend. Preventive maintenance and judicious rebuilding can work wonders on some old instruments, but only if excellent technical staff are in charge. In general, service from manufacturers is expensive and not always efficient. I believe that a university can make a profit by paying for a highly skilled cadre of technicians who can handle essentially all instruments. Third, some instruments built before the computer era can be upgraded successfully by addition of a computer and an interface. For example, a Picker, four-circle X ray diffractometer could be purchased last year for $12,500 and automated for $30,000 to produce an instrument superior in some respects to new ones costing over $100,000. There are thousands of X ray powder diffractometers that can be automated by addition of a stepping motor, an interface, and a computer for between $15,000 and $30,000; compare this with the $80,000–$100,000 for a new instrument. It is important to install some new instruments on a regular and continuing basis, but revamped older instruments can serve an important function, especially for teaching. I recommend that funds be made available for renovation and automation of as much existing equipment as possible. A careful choice must be made of the type of equipment. Thus, some electron microprobes have such poor optical and vacuum systems that automation is not worth the cost. Again, I emphasize the importance of first-rate technical staff and facilities, especially in teaching institutions, which are responsible for training a new generation of scientists. Fourth, I recommend that universities teach more courses on laboratory principles and practice. These might be staffed in part by the technicians mentioned above. Scientific societies should consider giving short courses on new techniques and should arrange for dissemination of appropriate information on upgrading old basic instruments.

Other questions that should be addressed include

1. What should be the distribution of research funds (e.g., from NSF) between equipment costs and other categories, such as salaries?
2. Is there a current shortage of trained technical staff? What are future prospects for industrial recruiters?
3. Should there be coordination between government laboratories and private institutions, and to what degree?
4. Is it important to find ways for U.S. companies to recapture instrument sales in areas now lost or almost lost to foreign companies (e.g., in X ray diffraction instruments)?
5. Should a program be established to cover costs of transferring older instruments from industrial companies and government laboratories to teaching institutions both in the U.S. and abroad?
6. Do some users treat instruments as 'black boxes,' and if so, should training programs based on fundamental principles be established?

We anticipate a thorough review of the instruments in a representative set of laboratories, and an appropriate questionnaire is being prepared. However, this will need to be supplemented by as much 'anecdotal' information as possible.

Please send your ideas, preferably in concise writing, with formal permission to quote them in a final report. If you wish to phone me, please do so, if at all possible on a Wednesday, at (312) 753-8632, 8:30 A.M.–7:00 P.M. I prefer this day for administrative and miscellaneous matters and try to keep other days for teaching and research.

Joseph V. Smith
President-Elect
VGP Section

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Cover. A woodcut by Fridtjof Nansen, oceanographer and polar explorer and Nobel Peace Prize Winner (1922), depicting himself strolling on the ice with a triple curtain-like form of the aurora overhead (from Nansen's Nord I, Takehelmen, 1911). Frontispiece from *Physics of Auroral Arc Formation, Geophys. Monogr. Ser.*, vol. 25, AGU, Washington, D.C. edited by S.-I. Akasofu and J. R. Kan. For details see p. 1155

News

Earth Dynamics Study

The 56 investigators in NASA's Crustal Dynamics Project met in September at the Goddard Space Flight Center to review the project, which will study the earth's tectonic plate movements, crustal deformation, and rotational dynamics. European investigators convened October 30. Using precise geodetic data obtained with such space techniques as laser ranging and radio interferometry, investigators will study regional crustal deformation in California, Alaska, and other regions of high earthquake activity; the current-day relative motion between the earth's major tectonic plates; the internal stability of the North American and Pacific plates; and variations in the Earth's rotation rate and position of its polar axis. The project will extend through 1986.

Two techniques have been developed to make precise measurements between two points separated by large distances (thousands of kilometers). The first involves laser ranging to artificial satellites and to the moon. The LAGEOS satellite, launched by NASA on May 4, 1976, into a nearly circular orbit at an altitude of 5800 km, is a sphere whose surface is covered with 426 optical-cube corner reflectors which reflect any incident optical signal back to the source. By accurately and repeatedly measuring the time for a laser pulse to travel to the satellite and return, the position of the ground laser can be determined with high accuracy. When similar measurements are made from a second station (which can be located on a different continent), the distance between the two stations can be determined with a precision of about 5 cm. Lunar reflectors were implanted by the crews of Apollo 14, 15, and 16, and by two Soviet unmanned Luna missions. In addition to studies of the earth, lunar laser ranging has provided valuable information on the dynamic motion of the moon and its orbit and has been used to study theories of general relativity.

The second technique, called Very Long Baseline Interferometry (VLBI), involves the analysis of radio signals emitted by quasars and other celestial objects. These emissions are received and recorded on magnetic tape by two or more radio telescopes separated by large distances. These signals are subsequently compared to determine the difference in the time at which the signals reached each telescope, and the time differences are analyzed to determine the precise distance between each of the stations. Currently, the precision of this technique is on the order of 3 cm. By making repeated measurements over a period of years, using both techniques, crustal motions as small as 1 cm per year can be determined. Current knowledge of the relative motions of the tectonic plates is based on paleomagnetic data and other information and is averaged over the past several million years of geologic time. These averaged rates are estimated to be between 1 and 20 cm·yr. Using laser ranging and VLBI, these movements can be directly measured for the first time, and tectonic models can be revised to reflect contemporary plate motion.

In California, Alaska, and other regions of high earthquake activity, the driving forces of plate tectonics cause a buildup of crustal strain near plate boundaries. When the resulting stress exceeds the strength of the underlying materials, the stress is released in the form of earthquakes or slow creep. A major objective of the Crustal Dynamics Project is to measure and analyze regional deformation and strain accumulation along major plate boundaries such as the San Andreas Fault in California, which separates the North American Plate from the Pacific Plate. This will help us to understand the basic mechanisms leading to earthquakes and eventually to the development of a reliable earthquake prediction model.

In order to measure the accumulation of crustal strain over an active tectonic region, measurements must be made at many sites. NASA has developed highly mobile systems, using both laser ranging and VLBI technology, which can easily relocate from one site to another within a matter of days. Mobile systems using VLBI techniques have been developed at the Jet Propulsion Laboratory, and mobile laser systems have been developed at Goddard Space Flight Center and the University of Texas.—*PMB* ⊠

Hot Plasma Zone Near Saturn

Investigators using data collected by Voyager 2 during its flyby of Saturn this past August have found a place in the solar system containing the hottest gas yet observed. Temperatures in a region of space around Saturn range from 300 million to nearly 1 billion° C. The hot gas is an enormous doughnut-shaped region encircling Saturn at an altitude ranging from 273,600 km above the planet's cloud top to as high as 724,000 km.

The discovery was announced at a colloquium at the Applied Physics Laboratory of The Johns Hopkins University, Baltimore, by S. M. Krimigis, chief scientist of the Applied Physics Laboratory Space Department, who is principal investigator of the Voyager Low-Energy Charged-Particle Experiment, which made the observations. The measurements were analyzed by a team that includes investigators from The Johns Hopkins University, the universities of Maryland and Kansas, Bell Telephone Laboratories, and the Max Planck Institute in Germany.

'The temperatures,' Krimigis said, 'are about 300 times hotter than the solar corona, and twice as hot as the Jupiter plasma cloud discovered by our instrument on Voyager in 1979.'

'The reason that the spacecraft survived passage through this region,' explains Louis Lanzerotti of Bell Laboratories, a coinvestigator of the experiment, 'is that the density of the gas is very small, only about 30 particles in a cubic foot; so, there were not very many ions hitting the spacecraft and heating it up.'

The low-energy charged-particle instrument is designed to measure fast (a few thousand miles per second) ions and electrons in the magnetospheres of the planets and in the interplanetary medium. The instrument can distinguish several elements, such as hydrogen, helium, oxygen, sulfur, sodium, and others; measure the direction in which these high-speed particles are moving; and the temperature of this particle population when the plasma is very hot (tens of millions of degrees). The instrument is also capable of identifying the equivalent of the Van Allen belts and radiation zones in the magnetosphere of the planets.

The region of space around Saturn occupied by the hot plasma torus seems to be centered around the orbits of Dione and Rhea, two of Saturn's icy moons, and to extend further away from the planet on the dayside than on the nightside, Krimigis said. He also noted that in this region of space Pioneer 11 and Voyager 1 experiments had shown the presence of a relatively 'cold' plasma (temperatures of a few million degrees), which was a thousand times denser than the hot plasma identified by Voyager 2. No obvious explanation was offered for the heating mechanism of this gas. [Source: NASA]—*PMB* ⊠

New Water Year Has Wet Start

Streamflow during October, the first month of the 1982 water year, was in the normal range over most of the country, but well-below normal streamflow still persists in the Southeast, according to the U.S. Geological Survey.

The water year used by hydrologists runs from October 1 of any calendar year to September 30 of the following calendar year, and it is designed to roughly follow the growing season and to begin and end during a period of generally low streamflow.

USGS hydrologists said that about 80% of the key index stations reporting across the country showed normal to above-normal streamflow during October. By contrast, 6 months ago, more than half of the key index stations reporting during May showed well-below normal streamflow—within the lowest 25% of record, that is, 75% of the time, flow will be equaled or exceeded.

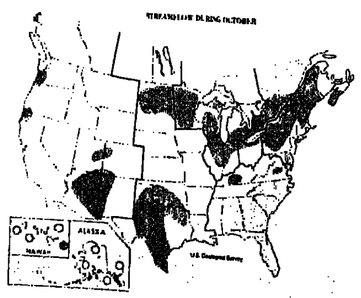
Although the nation's water resources picture is off to a generally wet start for the new water year, USGS hydrologists said that it will take several months of above-normal precipitation to reverse the effects of the previous dry months.

Streamflow throughout much of the Southeast remains well-below normal. Flows of more than half of the key index streams from Virginia south to Florida and west to Alabama were at well-below normal levels for October. Streamflow on all four key streams in Georgia was below normal for the fourth straight month.

In contrast, above-normal streamflow predominated in a broad regional band from New England through the Great Lakes states and into Minnesota and North Dakota. Large areas of above-normal streamflow were also reported in Arizona and New Mexico and in Texas and Oklahoma, where severe flooding boosted flows of many streams.

As an indication of the generally healthy water situation in much of the United States during October, combined flow of the nation's 'Big Five' rivers (Mississippi, St. Lawrence, Ohio, Columbia and Missouri) averaged 483 billion gallons a day (bgd), about 2% above normal. The combined flow of these rivers has been in the above-normal range now for five straight months. The Big Five rivers account for streamflow runoff in about half of the conterminous United States and provide a useful check on the status of the nation's water resources.

Individual flows of the Big Five for October: Mississippi River near Vicksburg, Miss., 178 bgd, 5% below normal and 21% below September; St. Lawrence River near Massena, N.Y., 193 bgd, 17% above normal and 1% above September; Columbia River at The Dalles, Ore., 55 bgd, 7% below normal and 8% below last month; Ohio River at Louisville, Ky., 23 bgd, 2% below normal and 20% below September; Missouri River at Hermann, Mo., 34 bgd, 12% below normal and 5% below last month. (Photo credit: U.S. Geological Survey, Department of the Interior.) ⊠



Above normal (within the highest 25 percent of record for this month).

In normal range

Below normal (within the lowest 25 percent of record for this month)

Conference Reviews R&D Budget

About 85 university officials, laboratory directors, industrial research executives, scientists, and engineers gathered in Washington, D.C., at the invitation of National Academy of Sciences President Frank Press, to discuss the outlook for and the implications of the federal research and development budget for fiscal 1982 and beyond. The consensus of the group is that President Reagan's proposed 12% across-the-board cut, if effected, would severely damage science; that the White House should review research funding to make more productive use of research dollars; that science and technology are vital to the Reagan administration's goals; and that basic research should take priority over development.

George A. Keyworth, director of the Office of Science and Technology Policy (OSTP), and Fred Khedouri, associate director for natural resources, energy, and science in the Office of Management and Budget (OMB), also attended the meeting on October 26 and 27. They advised the group to be realistic and not assume the worst case. In addition they told the conference that during this period of fiscal restraint growth will be restricted; nevertheless, science will be treated with sensitivity.

Fearing, however, that the restricted growth associated with the budget slicing will irrevocably harm science, the conference participants voiced their concerns to the Administration and Congress. Press emphasized that the gathering was not a confrontation or a lobbying effort.

Reagan's proposed reductions 'will do irreversible damage unless longer-term research, in contrast to development and demonstration, is protected,' according to a statement issued at the conference's conclusion. As examples, the assembled scientists pointed out that young investigators, early in their careers, would not receive support for their work. In addition, science teams would be broken apart, and the poor opportunities perceived by young people would reduce the supply of scientists.

This manpower problem concerns industry the most, according to Keith McHenry, vice president for research and development at the Amoco Oil Co. Henry Feshbach, physics department chairman at the Massachusetts Institute of Technology, noted that in the physical sciences the manpower numbers will be back 'to the pre-Sputnik era' if the proposed cuts are approved. Press added that such a trend would not be easily reversible because the cycle for 'building and rebuilding' science approximates 5 to 10 years.

The conference participants also agreed that 'continued sound investments in research and development by the federal government are essential to our national goals.' Their statement continued, 'Because of the important relationship between research, technology, and increased productivity, the expressed goals of this Administration for a strong economy and improved national security demand more, rather than less, investment in basic research.'

While recognizing the need for tightening the federal money belt, the participants urged the Administration and Congress to take an across-government view of R&D and to make budget adjustments while maintaining the basic sciences. OMB and OSTP were suggested as candidates for performing such a review. The group also asked that the government recognize that 'education in the sciences is inextricably linked to research' and urged that graduate student support be continued through research grants, fellowships, and traineeships.

Substituting a large part of government support with industry support was not an acceptable solution to the problem. 'The growing relation between universities and industry is laudable, and the nation can only benefit from these partnerships. Yet,' the scientists agreed, 'such a relation cannot become a substitute for the strong government-university partnership in support of basic research which now exists.'—*BTR* ⊠

Memorial Fund for Henry Faul

The University of Pennsylvania has established a memorial fund to honor Henry Faul, professor of geophysics. The fund will be used 'to remind future generations of Penn geology students of the effective and uniquely personal leadership role Henry played' in the geology department during the last 16 years, according to Robert Giegengack, department chairman. Faul died on September 16.

Contributions may be made to the trustees of the University of Pennsylvania for the Henry Faul Memorial Fund, c/o the Department of Geology, University of Pennsylvania, Philadelphia, PA 19104. ⊠

Geophysicists

Gordon J. Bell, 57, died on May 6, 1981. A member of the Meteorology Section, he joined AGU in 1974.

John D. Hale, 68, died on April 17. A member of the Tectonophysics sections, he joined AGU in 1948.

Lloyd Harrold, 73, died on September 16, 1981. A Life Member, he joined AGU in 1935. He was a member of the Hydrology Section.

Henry Hemple, 89, died on October 13, 1981. A Life Member, he joined AGU in 1933. He was a member of the Geodesy Section.

Jorgen Holmboe, 78, died recently. A Life Fellow, he joined AGU in 1936. He was a member of the Meteorology section.

Stephen W. Nile, 77, died on February 22. A member of the Seismology section, he joined AGU in 1947.

Gerrit H. Toebes, 54, died recently. A member of the Hydrology Section, he joined AGU in 1968.

New Publications

Modern X-Ray Analysis on Single Crystals

Peter Luger, Walter de Gruyter, New York, 312 pp., 1980, $48.00 (clothbound).

Reviewed by Paul B. Moore

One may ask 'Why a new book on crystal structure analysis?', and justifiably so. I was brought up on that great classic *X-ray Crystallography* by Martin Buerger, written some 40 years ago. It was, and still is, a gold mine of information, many tedious calculations of which Buerger did himself. But crystallography as science has its own autoimmune system. The science has become so fundamental and automated in rapid information retrieval that it is now a servant to other sciences. Crystal structures are solved no longer for their own sake but for the increase of knowledge of the chemical bond in whatever field it may be.

This pretty little book with its cartoons of baby's head and symmetry operations around it is ideal for the modern student who will probably use crystallography as a tool. Consider the chapters: matrices, vectors, diffraction theory (52 pp.), film methods, X-rays, choice of apparatus (59 pp.), crystal symmetry and space groups (65 pp.), diffractometers (29 pp.), phase problem (62 pp.), and refinement (36 pp.). Each is a good, thorough distillate of earlier works. Flow diagrams of symmetry operations appear, often a one-page encapsulation of what would formerly constitute a whole treatise. Most important for this book is a considerable discussion on computer-assisted structure analysis: direct methods and refinements. Small (but to the scientist, often crucially important!) details are not left out, for example assessing crystal quality.

In crystal structure analysis, as in other sciences, 'the mills of the gods grind slowly,' so as years pass, new and clever shortcuts are discovered. There is no competition: the world has two places. There are places for Buerger's classic work and for Luger's compact little book, which, by the way, generously refers to the varied classics in the field. This would be an excellent book for a graduate course in chemistry, geochemistry, etc., on a powerful and vital tool.

Paul B. Moore is a professor in the Department of the Geophysical Sciences at The University of Chicago.

AGU Geophysical Monograph, vol. 25, Physics of Auroral Arc Formation, *is based on the proceedings of the Chapman Conference on the Formation of Auroral Arcs. The conference was financially supported by the National Science Foundation, NASA, the Air Force Geophysical Laboratory, and the Lockheed Research Laboratory. The following essay, written by the conference coverer, surveys the subject of the conference.*

Physics of Auroral Arc Formation

S.-I. Akasofu and J. R. Kan (Eds.), *Geophys. Monogr. Ser.*, vol. 25, AGU, Washington, D.C., xii + 465, 1981, $25.00.

The aurora has been one of the most challenging problems in geophysics, but it has finally begun to yield its secret. The polar aurora appears in a narrow belt called the 'auroral oval,' which surrounds the geomagnetic pole. A woodcut of the aurora by the great polar explorer Fridtjof Nansen (see this week's cover of *Eos*), illustrates, fairly accurately, the thin curtain-like form of the aurora, extending from the zenith to the horizon. When this curtain-like form is observed from a distant point outside (south of) the oval, it appears as an arch-like luminosity above the northern horizon. It was this particular form that was officially classified as an 'arc' by Carl Störmer, who produced the first catalog of the auroral forms. This is the origin of the term arc, although we now use it to describe the curtain-like discrete form.

There is little doubt that the aurora results from an electrical discharge process powered by the solar wind-magnetosphere dynamo. It has also been found that there exists a potential drop of the order of a few kilovolts along auroral field lines, which is largely responsible for the acceleration of auroral particles. Until several years ago, it had been thought that a field-aligned potential drop was extremely unlikely to occur in a collisionless magnetospheric plasma. In fact, this was even a 'forbidden' thought for many years.

These remarkable advances in auroral physics during the last several years are a result of extensive observations of auroral particles, field-aligned currents, and electric fields, as well as theoretical studies of the relationship among these observations. In July 1980, an AGU Chapman Conference was held at the University of Alaska to discuss the subject of the acceleration process of the auroral particles.

Two important goals were set for the conference: (1) identification of possible plasma processes that can be responsible for the cause of the potential structure, and (2) exchange of ideas, among theorists and experimenters, on relevant plasma processes.

During the last decade, several interesting observations and theoretical studies have contributed to revealing the geometry of the auroral potential structure. Available observations suggest that equipotential contours in a meridian plane cross section of the structure are V shaped or S shaped or a combination of the two. For the V shaped geometry, electrons will be accelerated more along the center line than along its northern and southern skirts. It appears that the V shaped potential structure has at least two scale sizes: The first has a latitudinal scale of a few hundred kilometers, and the second has a latitudinal scale of a few kilometers or less embedded in the larger-scale one.

There was little doubt among the conference participants that the electric currents along geomagnetic field lines (field-aligned currents) are closely associated with the formation of potential structure. It is likely that there is a limit to the current density ($\sim 10^{-6}$ amp/m^2) of upward (field-aligned) currents carried by magnetospheric electrons owing to the mirroring of these electrons as they descend toward the polar ionosphere. However, when the solar wind-magnetosphere dynamo imposes more than the limiting current density, the magnetosphere-ionosphere system develops a potential drop to allow the electrons to carry more current to the ionosphere.

In the past we have identified double layers, electrostatic shocks, differential pitch-angle anisotropy, anomalous resistivity, and others as possible mechanisms for supporting the potential drop along field lines. The importance of a double layer in accelerating auroral particles was suggested first by H. Alfvén many years ago. On the other hand, the pitch-angle anisotropy is an important ingredient in extending the field-aligned scale length of the double layer. Further, anomalous resistivity may provide additional potential drop in the double layer.

There are a number of fascinating phenomena associated with the auroral potential structure. They are well summarized by Figure 1. These phenomena serve in diagnosing plasma processes that are taking place in the auroral potential structure. For example, during the conference, experimenters and theorists came close to the agreement that the auroral kilometric radiation (AKR) is generated by gyration of electrons trapped in the auroral potential structure. Therefore, the spectral characteristics of the AKR provide important information on the trapped electrons, which are important for maintaining the double layer potential. It should also be mentioned that the spectra of auroral electrons are not necessarily in full agreement with what the potential structure predicts.

It was fortunate that several plasma physicists participated in the discussion of plasma processes associated with the formation of the auroral potential structure from a variety of viewpoints, including computer plasma simulation studies and laboratory experiments. In the history of magnetospheric physics, it may be that the auroral potential structure is the first subject so comprehensively studied by workers of diverse expertise. Many participants recognized the usefulness of computer simulation studies of space plasmas.

One of the most important future problems will be to understand the formation of the auroral potential structure as an integral part of the magnetosphere-ionosphere system, rather than as a plasma region isolated from the rest.

S.-I. Akasofu
Geophysical Institute
University of Alaska

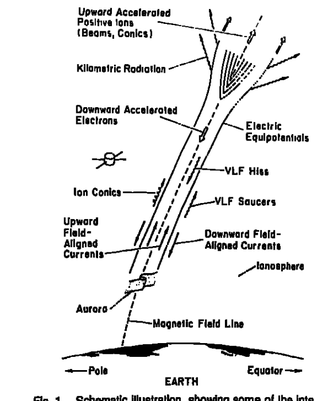


Fig. 1. Schematic illustration, showing some of the interesting features associated with the auroral potential structure (courtesy of P. B. Dusenbery).

Classified

Structural Geologist or Geophysicist/ Washington University. The Department of Earth and Planetary Sciences has available a tenure track or tenured position beginning in the fall of 1982 for a structural geologist or geophysicist. Preference will go to candidates with research interests in field studies or measurements pertaining to the formation and evolution of continental crust. Interests of the candidate should complement those of present faculty in geochemistry, geophysics, and economic geology of Precambrian regions.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references to Larry Haskin, Chairman, Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130. Applications received through February 15, 1982.

Washington University is an equal opportunity/affirmative action employer.

Metamorphic Geologist. The Department of Earth Sciences of Montana State University anticipates a new position in geology and invites applications for a tenure track position at the assistant professor level beginning either June or September, 1982. We seek a field-oriented metamorphic geologist. A background in economic geology or tectonics is desirable. Candidates must be interested in teaching introductory geology and undergraduate mineralogy-petrology courses, and will be expected to participate in summer field instruction. Completion of Ph.D. prior to appointment is strongly preferred. Our department has 11 faculty and is multi-disciplinary. B.S. options in geology, geophysics, geographical planning, geography, and meteorology and an M.S. option in geology are currently offered.

Send resume, transcripts, and three letters of recommendation by February 10, 1982 to: Dr. Robert A. Chadwick, Department of Earth Sciences, Montana State University, Bozeman, MT 59717. Montana State University is an affirmative action/equal opportunity employer.

Physical Oceanographer. The School of Oceanography, Oregon State University, is soliciting applications for an assistant or associate professor, depending on experience. Applicants may be observationalists or theoreticians, but must have a Ph.D. in the physical sciences and have demonstrated ability to conduct independent high-quality research and obtain research funding. Duties include teaching and supervision of graduate students. Interested candidates should submit a resume and names of three references by 1 January 1982 to G. Ross Heath, Dean, School of Oceanography, Oregon State University, Corvallis, Oregon 97331.

Affirmative Action Equal Opportunity Employer

Planetary Scientist/Washington University. The Department of Earth and Planetary Sciences has available a tenure track or tenured position beginning in the fall of 1982 for a geoscientist with research interests in such areas as planetary geophysics, planetary materials, or planetary atmospheres. Preference will be given to research areas that complement the current departmental program.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and training; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references to Larry Haskin, Chairman, Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130. Applications received through February 15, 1982.

Washington University is an equal opportunity/affirmative action employer.

Assistant Professor: Princeton University. We seek a geologist trained in Sedimentology and or Paleontology with research interests in Phanerozoic or Precambrian sedimentary geology and history. Appointment is to be effective September 1982 or later depending on availability of candidate.

Applicants should send resumes to: Sheldon Judson, Chairman, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08544.

For further information: Robert Hargraves, Chairman, Search Committee, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08544.

Princeton University is an equal opportunity affirmative action employer.

Virginia Polytechnic Institute and State University: Senior Research Associate. Interesting and abundant research and publishing opportunities, including new University-owned MOS-10 VAX/ROSEIS system, VAX 11/780 computer. Must have experience in theory and application of reflection seismology, and be interested in the application of reflection seismology to the solution of geologic problems.

Send resumes to: Dr. D. R. Wones, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0798.

The University is an equal opportunity/affirmative action employer.

Faculty Positions: Earth Sciences. SUNY Stony Brook is seeking candidates for two tenure track appointments and one or more visiting professorships for the academic year 1981–82. Rank and salary are dependent on experience and qualifications. Areas of specialization for the tenure track positions include structural geology, tectonophysics, geophysics, mineralogy, petrology, geochemistry, and mineral resources. Duties include teaching graduate and undergraduate courses and conducting original research. The areas of specialization for the visiting professorships are: mineralogy, crystallography, or mineral physics. Send resumes and names of three references to: Professor Gilbert N. Hanson, Department of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an equal opportunity/affirmative action employer. AK#2313.

Structural Geologist/University of Wyoming. The University of Wyoming, Department of Geology and Geophysics seeks applicants for a tenure track appointment in structural geology expected to be available beginning fall semester 1982 or earlier. Duties will include teaching of undergraduate and graduate courses in structural geology, supervising MS and PhD theses, and research in structural geology. Appointment at assistant professor level is preferred, but applicants requesting appointment at higher rank will be considered. Salary open. Applicants must have PhD degree and be versed in quantitative theory as well as field applications or modern structural geology and regional tectonics.

Applicants should provide, by January 1, 1982, a resume, three letters of reference, and a letter of application including a statement of current research interests and courses which the applicant feels qualified to teach. Applications should be sent to:

Dr. Robert S. Houston Head
Department of Geology and Geophysics
University of Wyoming
Laramie, Wyoming 82071-3006.

The University of Wyoming is an equal opportunity affirmative action employer.

Research Associate Position/University of Arizona. The Lunar and Planetary Laboratory anticipates that a postdoctoral position will become available in January 1982. This is a one year, nonrenewable position. The position will involve laboratory studies of the infrared spectral reflectances of meteorites, terrestrial silicates and ices. These data will be used for interpretation of high-resolution spectra of asteroids and other planet satellites. Applicant should have experience with IR spectrometers at the telescope and in the laboratory.

Vita, bibliography, and three letters of reference should be sent by December 31, 1981 to:

Dr. Larry A. Lebofsky
Lunar and Planetary Laboratory
University of Arizona
Tucson, AZ 85721

Equal opportunity affirmative action Title IX Section 504 employer.

University of Hawaii Faculty Positions. The Department of Geology and Geophysics and the Hawaii Institute of Geophysics of the University of Hawaii are seeking applicants for two tenure track positions becoming available January 1, 1982. Applicants should have specialization in (1) *marine geophysics* with emphasis in one or more of the fields: marine seismology, magnetics and gravity; or (2) *marine geology sedimentology*. One of these positions will be filled at a rank of full professor, the other at assistant or associate level.

Applicants should have demonstrated ability to conduct and promote marine research commensurate with the level of the application. Ability to teach at all levels is expected. The positions will be joint ones on an 11-month basis with the Department and the Institute and will involve both teaching and research responsibilities. Apply with resume, expected level of appointment and the names of 3 referees to Chairman, Personnel Committee, Department of Geology and Geophysics, University of Hawaii, Honolulu, Hawaii 96822.

Closing date for applications is January 1, 1982. The University of Hawaii is an affirmative-action/equal opportunity employer.

THE OHIO STATE UNIVERSITY

The Department of Geology and Mineralogy invites applications for tenure track positions in

HYDROGEOLOGY
AQUEOUS OR ORGANIC GEOCHEMISTRY
GEOPHYSICS OR SEISMOLOGY
SEDIMENTOLOGY OR SEDIMENTARY PETROLOGY

Ph.D. required. Successful applicants will be required to teach graduate and under graduate courses and conduct research. Positions open Fall of 1982, possibly sooner. Rank and salary dependent on qualifications. Send resume, with statement of research record and interests and arrange for at least three letters of references to be sent to.

Peter-Noel Webb, Chairman
Department of Geology and Mineralogy
107 Mendenhall Laboratory
125 South Oval Mall
Columbus, Ohio 43210.

by or before February 1, 1982. Further information on these positions may be obtained by calling (614) 422-2721.

An equal opportunity/affirmative action employer.

SENIOR GEOPHYSICIST

A leader in the field of exploration geophysics for both resource and engineering applications located in New England is expanding its staff and has immediate openings for highly qualified geophysicists to work on both national and overseas projects.

Background must include Ph.D. or Masters and 5 years + experience in industry. Primary area of expertise should be interpretation of seismic data, a familiarity with potential field studies is also highly desirable. Job responsibilities will include: design and management of geophysical data acquisition programs for engineering and exploration programs throughout the world; analysis and interpretation of numerous types of geophysical data and development of reports. Salary is negotiable.

If you are interested in joining a growing and dynamic organization that for over twenty-five years has provided industry and government with state-of-the-art geophysical services, then these are excellent career possibilities for you. In addition to positions they also are stimulating and rewarding professional challenges which offer the opportunity for management responsibility. Located in an attractive New England setting and provides excellent benefits and salary opportunities. If you would like to be considered for one of these positions, please forward your resume and salary history to:

Mr. John Doherty
Post Office Box 550
Lyons Street
Westboro, MA 01532.

Engineering Geologist/Geophysicist. The Department of Geological Sciences, University of Saskatchewan, has a vacant tenurable position in engineering geology/geophysics. Applicants should be qualified to teach undergraduate and graduate courses and to conduct research in engineering geology. A background in structural geology may be appropriate. Well-equipped facilities are available for research in rock mechanics, fluid flow through porous media, acoustic, and electrical properties of rocks, and permafrost. Good opportunities exist for joint research with qualifications and experience. Send applications, detailed personal resume including the names of at least three referees, and other supporting data to Dr. W.G.E. Caldwell, Head, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0.

Please note: until November 15, 1981 consideration will be given only to applicants who are Canadians or landed immigrants, after that date all applications will be considered.

Petrologist-Economic Mineralogist/University of Oklahoma. Applications are invited for a tenure-track position, effective September 1, 1982 at the assistant professor level, in petrology and economic mineralogy. The successful applicant is expected to teach graduate courses in his/her specialty, to help teach undergraduate courses in mineralogy-optics-petrography, and to pursue an active research program. Consulting and interacting with mining companies are encouraged.

The University of Oklahoma has made a major commitment to diversify the program in the School of Geology & Geophysics. As a result five tenure-track positions are open for the fall of 1982. Six new faculty were added to the School in the fall of 1981 (bringing the total full-time faculty to 15), and an additional six positions will be available during 1983–1985. A new building that will house the School is in the design stage, and the successful applicant will participate in equipping it.

The Ph.D. degree is required for this position. Preference will be given to petrologists with a strong chemistry background and with a demonstrated interest in the economic geology of metallic and non-metallic mineral deposits. Qualified applicants should arrange to send transcripts of all college and university work, resume, statement of research interests, and three letters of reference to: Dr. Maryellen Cameron, School of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma, 73019. Deadline for applications is December 31, 1981. Faculty members from the School will be interviewing at the November G.S.A. meeting in Cincinnati, Ohio, and at the December A.G.U. meeting in San Francisco, California.

The University of Oklahoma does not discriminate on the basis of race, or sex, and is an equal opportunity employer.

Faculty Positions. *Two Faculty Positions in Geology:* Tenure-track positions in geology, assistant professorships, Ph.D. preferred or equivalent experience. Fall 1982.

Petrologist-Mineralogist. Candidate must be able to teach introductory geology, mineralogy, petrology, geochemistry, and optical mineralogy/petrography.

Invertebrate Paleontologist-Soft-Rock Geologist. Candidate must be able to teach courses in invertebrate paleontology, micropaleontology, sedimentation, and historical geology. Additional expertise in recent marine environments highly desirable.

Applicants are expected to do research in their areas of expertise, and to lead students' field trips. Strong teaching and research commitments expected. Submit applications with resume and copies of transcripts, and have three letters of recommendations sent to the Chairperson, Department of Earth & Space Sciences, Indiana University-Purdue University at Fort Wayne, Fort Wayne, Indiana 46805.

Indiana University-Purdue University is an equal opportunity/affirmative action employer.

Petrology/Geochemistry/ Florida International University. Applications are invited for one tenure track position (assistant professor) available from August 1982. The successful candidate will be expected to teach at the undergraduate level and pursue a vigorous research program. The applicant should have a background in petrology and geochemistry. Highly qualified candidates in the areas of geophysics or hydrogeology may also be considered. Applicants should have a Ph.D. degree. Closing date March 15, 1982. Applications including a curriculum vitae, research interests, and three letters of reference should be sent to:

Dr. Leonard Keller, Chairman, Department of Physical Sciences, Florida International University, Tamiami Trail, Miami, Florida 33199

FIU is a member of the State University System of Florida and is an equal opportunity/affirmative action employer.

Physical Oceanographer. Royal Roads Military College expects to have a tenure track vacancy in Department of Physics effective 1 July 1982. Candidates should hold doctorate or near doctorate in physical oceanography preferably with experience in digital hardware and microcomputer applications. Appointment expected to be made at assistant professor level but salary and rank dependent on qualifications and experience. Relocation expenses can be provided. Duties include undergraduate teaching in physics and physical oceanography, and research in marine science. Applications should include complete dossier and names of three references and be sent to: Dr. E.S. Graham, Principal, Royal Roads Military College, FMO Victoria, B.C. V0S 1B0.

This competition is open to both men and women. Knowledge of English only is required. Only Canadian citizens or Landed Immigrants need apply.

Toute information relative a ce concours est disponible en français et peut être obtenue en écrivant à Dr. Graham.

Iowa State University of Science and Technology/Department of Earth Sciences.

Applications are invited for two tenure track faculty positions. The rank for each is at the assistant or associate professor level, dependent upon qualifications. The successful applicants will be expected to develop strong research and graduate student programs. Teaching duties will include undergraduate and graduate courses in the areas of expertise.

Mineral Resources/Economic Geology: One position is in mineral resources/economic geology. An applied field orientation is preferred. Iowa State has established a Mining and Mineral Resources Research Institute and an interdepartmental minor in Mineral Resources in order to support and develop research and education in this area. In addition to the appointment in the Department of Earth Sciences there will be full opportunities to interact with these programs.

Geomorphology: The second position is in the general field of geomorphology. Additional expertise in an area related to geomorphology, such as groundwater, engineering geology or remote sensing is also desired. A person with an applied field orientation is being sought.

Each appointment will be on an academic year basis. Opportunities are available for summer teaching appointments. Salaries will be commensurate with qualifications. Application deadlines for both positions are February 15, 1982; later applications will be accepted if a position is not filled. Positions are both currently available and are expected to be filled no later than fall, 1982. For application information please write to:

Bert E. Nordlie
Department of Earth Sciences
253 Science I
Iowa State University
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

Selenologist/University of Utah. Search extended: the University of Utah is expanding its geophysics program in the Department of Geology and Geophysics by adding a tenure track faculty member in selenology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic reflection, seismic imaging, and theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses, and to pursue an active research program with graduate students. The department has modern teaching and research programs in geology and geophysics, and has close associations with the numerical analysis and data processing groups in computer science, electrical engineering and mathematics. The geophysics component of the department has strong research and teaching programs in seismology, electrical and electromagnetic methods, thermal properties of the earth, and potential fields. Current research in seismology includes: seismological and earthquake research utilizing a new PDP 11/70 computer with plotter and terminals; monitoring of the intermountain seismic belt by a 55 station telemetered network utilizing a new on-line PDP 11/34 computer; major experiments in seismic refraction profiling, investigations of seismic propagation from synthetic seismograms, application of inverse theory to seismology, seismic properties of volcanic systems and allied research in tectonophysics. The closing date for applications is December 31, 1981. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference to William F. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

University of Utah is an equal opportunity/affirmative action employer.

Geophysical Fluid Dynamicist/Physical Oceanographer. Applications are solicited for a junior faculty position in ocean physics or dynamics to begin in the academic year 1982–83. Areas of interest to the Department include analytical, numerical and laboratory modeling of physical processes and phenomena in the sea.

Yale University is an equal opportunity/affirmative action employer and encourages women and members of minority groups to compete for this position.

Curriculum vitae, publications, and the names of three or more referees should be sent by 31 December 1981 to: Robert S. Gordon, Chairman, Department of Geology and Geophysics, P.O. Box 6666, New Haven, CT 06511.

Princeton University/Water Resources Program, Department of Civil Engineering. Department of Civil Engineering invites applications for a tenure track, three-year appointment at the assistant professor rank beginning on or before September 1982. Responsibilities include graduate and undergraduate teaching in hydrology and water resources, and participation in research into either hydrological processes associated with infiltration and unsaturated flow or chemical processes and transport in the unsaturated zone. Candidate must have Ph.D. degree with demonstrated teaching ability and scholarship.

Submit resume and references to:

Eric F. Wood, Director
Water Resources Program
Department of Civil Engineering
Princeton University
Princeton, NJ 08544.

Princeton University is an affirmative action/equal opportunity employer.

Faculty Positions Department of Geology/ The University of Alberta. The Geology Department has one permanent faculty position available (subject to funding) July 1, 1982. We invite applications from qualified individuals for appointment at the assistant or associate professor level in any of these areas: geomorphology, mathematical geology, engineering geology, process sedimentology and structural geology.

Preference will be given to those applicants who demonstrate an ability to pursue a vigorous research program applying modern concepts and techniques in solving geological problems. The candidate is expected to teach an undergraduate course in quantitative geomorphology, course(s) in his or her specialty, including if qualified, geostatistics. The position also involves supervising Masters and Ph.D. students. A Ph.D. is required and salary is commensurate with education and experience. Canadian citizens and permanent residents will be given preference.

Interested applicants should submit a résumé, publications and names and addresses of three (3) referees to Dr. N.W. Rutter, Chairman, Department of Geology, University of Alberta, Edmonton, Alberta, Canada T6G 2E3. Closing date for applications is February 15, 1982.

The University of Alberta is an equal opportunity employer.

University of Utah: Faculty Positions. The Department of Geology and Geophysics invites applications for four tenure track positions at the assistant to associate professor level.

1) *Economic Geology:* The specific area of expertise is open, however, preference will be given to candidates whose research interests are in geological, geochemical, or petrological characteristics of metallic mineral deposits.
2) *Sedimentary geology:* Applicants should have research interests in modern or ancient sedimentary basins.
3) *Seismology:* Applicants with backgrounds and specialties in seismic reflection, seismic imaging or theoretical seismology will be given preference.
4) *Potential fields:* Geophysicist with specialty in potential theory including gravity and magnetics. (The closing date for this position is January 31, 1982).

A Ph.D. or equivalent is required. The vacancies are to be filled by September 1982; the closing date for applications for positions 1–3 is December 31, 1981. Applicants should submit a vita, transcripts, a letter describing his/her research teaching goals, and names of five persons for reference to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

The University of Utah is an equal opportunity/affirmative action employer.

Positions in Oceanography/VIMS. The Virginia Institute of Marine Science (VIMS)/School of Marine Science invites applications for two state funded, oceanography research and teaching positions at the levels of Senior Marine Scientist. VIMS is a broad-based marine science establishment with a mission to provide sound and timely advice to executive agencies and the legislature and to conduct in-house research programs. The School of Marine Science offers M.A. and Ph.D. programs with a faculty of 66 and 139 graduate students.

HEAD, DEPARTMENT OF GEOLOGICAL OCEANOGRAPHY (#113)

Applicants are sought with research interests in estuarine sedimentary geochemistry, dynamics of cohesive sediment transport, or estuarine and coastal morphodynamics. For further information contact Dr. Robert Byrne (VIMS), 804-642-2111 (Ext. 173).

ESTUARINE AND COASTAL HYDRODYNAMICS (Position #204)

A physical oceanographer with a strong interest in interdisciplinary approaches to complex estuarine and continental shelf problems is desired. For further information contact Dr. Bruce Nelson (VIMS), 804/642-6131 (Ext. 244).

Candidates for both positions should have established research credentials and be dedicated to furthering the research and educational programs of the Institute. Demonstrated ability to generate extramural support is expected. Salary range is $24,972 to $34,107 and faculty rank is commensurate with qualifications.

Applicants should send a comprehensive curriculum vita, reprints, and at least three letters of recommendation by February 1, 1982, stating specific position of interest, to: Employment Manager, Personnel Office, College of Wm & Mary, Williamsburg, VA 23185.

An equal opportunity/affirmative action employer.

University of North Dakota. Applications are invited for two tenure-track appointments in the Department of Geology, beginning January 1982:

(1) petroleum geology or related fields
(2) one of the following areas
low-temperature geochemistry
carbonate petrology
economic geology

The first position will include teaching 1 or 2 courses per year in petroleum geology. Both positions require teaching undergraduate and graduate courses in the area(s) of expertise, directing graduate student research at the MS and PhD levels, and developing an active research program.

The Department has nine full-time faculty, two adjunct faculty, about 150 undergraduates and 50 graduate students. Association with the North Dakota Geological Survey includes access to complete subsurface records, cores and samples for 9,000 wells in the Williston Basin. Proximity to the Williston Basin and Canadian Shield provides abundant opportunity for research in sedimentary, igneous, and metamorphic petrology, and economic geology. Excellent physical facilities, the state core and sample library, and excellent photo, map, and book collections are available.

The Ph.D. is required, salary and rank are open and competitive. Applications will be accepted until suitable candidates are found. Applicants should submit complete resumes, including education, previous experience, teaching and research interests, and at least three letters of reference to:

Dr. Richard D. LeFever
Chairman, Search Committee
Department of Geology
University of North Dakota
Grand Forks, ND 58202

STUDENT OPPORTUNITIES

Graduate Teaching & Research Assistantships/University of Houston. Graduate teaching & research assistantships available to qualified persons interested in Space Physics at the University of Houston. Our experimental program features rocket & balloon-borne studies of the ionosphere & magnetosphere-ionosphere coupling. Emphasis has been on active experiments, most recent being a rocket-balloon campaign at Siple station, Antarctica in December 1980. Future work includes a study of pulsating aurora & participation in Waterhole II, an auroral quenching experiment. The theoretical program is on plasma waves in the solar wind & modeling of phenomenon related to current experiments. Assistantships for first year students begin at $600 mo along with out of state tuition waivers. Graduate Chairman, Physics Dept., University of Houston Central Campus, Houston, TX 77004. EOE

Graduate Research Assistantships in Physical Oceanography. Opportunities for graduate study with Research assistantship available for students interested in M.S. or Ph.D programs. A summer program with stipend is open to college juniors. Write: Douglas Caldwell, School of Oceanography, Oregon State University, Corvallis, OR 97331

Graduate Assistantships/Fellowships in Applied Paleomagnetic Research. Opportunities for study, with research assistantships, available for students interested in M.Sc. or Ph.D programs at the Colorado School of Mines. Research topics center around applied paleomagnetic investigations in economic geology, structural geology and stratigraphy/diagenesis and include such areas as the Stillwater Complex, western (Cenozoic volcanics-plutons) and eastern (core complexes) Basin and Range, central Colorado and the Powder River Basin. Students with undergraduate majors in geology, geophysics and physics are encouraged to apply. Detailed information can be obtained from:

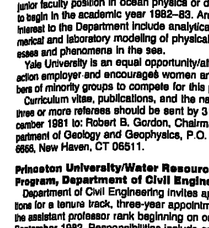
John Geissman
Department of Geology
Colorado School of Mines
Golden, Colorado 80401
(303) 279-0300 Ext. 2803

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

"Optical Properties of Clouds." A Workshop Report, edited by Peter V. Hobbs and Adarsh Deepak. This 29 page volume contains the report and recommendations of the Workshop "Clouds: Their Formation, Optical Properties, and Effects," Williamsburg, Virginia, May 14-15, 1980, sponsored by Army Atmospheric Sciences Laboratory and Army Research Office. Copies available from Circulation Dept., Spectrum Press, P.O. Box 730, Hampton, Virginia 23666 for $3.50 each (plus 4% sales tax—Virginia residents only, overseas postage and handling $1.00 surface, $3.00 airmail).

COAL DEPOSITS. If you are financing, planning, designing, exploring, drilling, or digging in connection with any form of energy, you need this complete, up-to-date book about the world's coal deposits. Includes production and reserves for mines. Hardcover. 6 × 9 inches, 590 pages. Table of contents, drawings, index, references. 1980. $156. Tatsch Associates, 120 Thunder Road, Sudbury, MA 01776.

AGU



Sonnerup

B. U. Ö. Sonnerup—New JGR-Blue Editor

'JGR is the foremost place to publish research in space physics. You really can't be in this field without having the journal right at your elbow,' said Bengt U. Ö. Sonnerup, the new editor of the space physics section of the *Journal of Geophysical Research*. He will formally begin his 4-year term on January 1, succeeding George Siscoe. Sonnerup has been receiving articles for the journal since October 1.

Sonnerup, whose research specialty is magnetopause dynamics, came to the United States from Sweden in 1958 and became involved with magnetospheric science when the field was first blooming.

'What brought me here, I think it's fair to say, was the desire to have a little bit of adventure,' Sonnerup said. He had been working in industry in his native country before he was accepted as a graduate student at Cornell, where he earned his master's and doctoral degrees in aerospace engineering. 'My original intention was just to stay for a year. However, I enjoyed being a graduate student. In particular,' he said, 'I got into contact with an exciting new field: magnetohydrodynamics.'

Sonnerup remained at Cornell as a postdoctoral fellow, working with Thomas Gold. 'It was after I spent a year with him that I decided I didn't want to go back into industry.' He did, however, return to Sweden for 2 years, where he worked at the Royal Institute of Technology's Department of Plasma Physics with Hannes Alfvén. 'I found pretty quickly, though, that the opportunities for doing research and teaching are greater in the U.S. than in Sweden,' he said. 'It is true, of course, that in terms of space research, all of the action was in the U.S. at that time.' He returned to the U.S. in 1964.

Now, as the Sydney E. Jenkins Professor of Engineering at Dartmouth College, Sonnerup, a theoretician, researches the structure and dynamics of the magnetopause (the boundary between the earth's magnetic field and the ionized gas streaming out from the sun) and of the adjoining plasma boundary layer. In addition to teaching and doing other research on the magnetosphere, he studies the energy-release mechanism in solar flares and the energization of charged particles at shock waves.

His experience with JGR-Blue comes not only from the numerous articles he has published in the journal but also from his stint as associate editor from 1972 to 1974. Sonnerup hopes to make a smooth transition from the former editor to himself. In fact, Sonnerup met with Siscoe in September to review the editorial process.

'I feel that the past editors have done an excellent job,' he emphasized. 'I intend to maintain the very high quality of the journal.' Sonnerup said that once he has settled in, he will write an editorial in the journal to explain his editorial policy and what role he feels JGR does and should play in the space science community. Briefly, he commented, JGR should be an integral part of the ongoing scientific process. As such, published articles should serve not only to document completed research, but also to advance new explanations and hypotheses. 'The journal, at least in my experience, is quite willing to accept those hypotheses as long as they are clearly stated and appeal to some kind of a sound observational or theoretical basis. . . . The publishing of such new ideas is absolutely essential to the scientific process.'—*BTR*

AGU Congressional Science Fellowship

The individual selected will spend a year on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science, be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to $25,000 plus travel allowances.

Interested candidates should submit a letter of intent, a curriculum vitae; and three letters of recommendation to AGU. For further details, write Member Programs Division, Congressional Fellowship Program, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

Deadline: March 31, 1982.

JGR-Red Editor for 1983–1986 Term

Thomas J. Ahrens will complete his term as editor of the *Journal of Geophysical Research*—Red at the end of 1982. A selection committee has been appointed to recommend candidates to the AGU president. Nominations for the editor for the red section of JGR for the term 1983–1986 are now being accepted. Those who are interested in serving as editor, or who wish to suggest candidates, should send recommendations by February 15, 1982, directly to

American Geophysical Union
2000 Florida Avenue, NW.
Washington, D.C. 20009
Attention: JGR Search Committee

Nominations for Medals and Awards

William Bowie Medal. Awarded for outstanding contributions to fundamental geophysics and for unselfish cooperation in research.

Maurice Ewing Medal. Honors an individual who has led the way in understanding the physical, geophysical, and geological processes in the ocean; ocean engineering, technology, and instrumentation; or who has given distinguished service to the marine sciences.

James B. Macelwane Awards. Up to three awards are presented each year for significant contributions to the geophysical sciences by a young scientist of outstanding ability. Recipients must be less than 36 years old.

Robert E. Horton Medal. Awarded for outstanding contributions to the geophysical aspects of hydrology.

Letters of nomination outlining significant contributions and curriculum vitae should be sent directly to the appropriate committee chairmen: *Bowie Medal*—George D. Garland, Department of Geophysics, University of Toronto, Toronto 5, Ontario, Canada; *Ewing Medal*—Robert O. Reid, Department of Oceanography, Texas A & M University, College Station, TX 77843; *Macelwane Award*—Manik Talwani, Lamont-Doherty Geological Observatory, Palisades, NY 10964; *Horton Medal*—Peter S. Eagleson, Department of Civil Engineering, Building 48-335, Massachusetts Institute of Technology, Cambridge, MA 03139.

DEADLINE FOR NOMINATIONS IS DECEMBER 15, 1981

Meetings

Penrose Conferences

Three Penrose Conferences were recently announced by the Geological Society of America. Conference titles are 'Tectonic History of the Ouachita Orogen,' 'Origin of Fluids and Metals in Porphyry and Epithermal Mineral Deposits,' and 'Models of Diagenesis in Clastic Reservoirs.'

Slated for May 23–28, 1982, at DeGray State Park Lodge in Arkadelphia, Ark., 'Tectonic History of the Ouachita Orogen' will feature discussions on the environments of deposition and tectonic framework of Early to Middle Paleozoic strata; provenance and tectonic framework of the carboniferous flysch; the Penion-Broken Bow uplift as a subduction complex; and the regional tectonic setting of the Ouachita orogen. The conference will include a field trip in the Ouachita Mountains surrounding DeGray Dam and Lake Ouachita. An optional field trip will be conducted May 23, before the conference begins, to the eastern outcrops of the Ouachita Mountains in Arkansas. The Ouachita orogenic belt extends from the southwestern Appalachians to the Marathon region of Texas and into Mexico.

To attend, contact either of the convenors, William A. Thomas or George A. Viele, by February 15. Indicate your interest in the conference and in the optional field trip. Also, describe areas of discussion to which you can contribute. Write to Thomas, Department of Geology, University of Alabama, University, AL 35486, or to Viele, Department of Geology, University of Missouri, Columbia, MO 65211.

The conference 'Origin of Fluids and Metals in Porphyry and Epithermal Mineral Deposits' will be held August 8–13, 1982, at the Holiday Inn in Dillon, Colo. Topics to be covered include the environment's role in the emplacement of plutons in the upper crust; the relation of the metal content and mineral assemblages of deposits to plutons; the production of the chemical nature of intruding magmas from the resulting plutons; and the conditions under which a pluton will produce a porphyry-type deposit, a vein deposit, or both. Two 1-day field trips will include surface tours of the Idaho Springs-Central City and Jamestown mining districts and an underground tour of the Henderson molybdenite deposit. There will be optional half-day surface field trips to other mining districts in central Colorado.

Applications to attend the conference should be sent to Jim LeAnderson, Department of Geological Engineering, Colorado School of Mines, Golden, CO 80401; deadline is April 20. Persons interested in giving an oral presentation or a poster session should submit a title and topic description by February 28. Convenors are LeAnderson, Steve Ludington, and Art Bookstrom.

'Models of Diagenesis in Clastic Reservoirs' is scheduled tentatively for August 15–20, 1982, in Kailua, Kona, Hawaii, following the Clay Mineral Society Annual Meeting on August 8–14 in Hilo, Hawaii. The conference will examine diagenetic models pertaining to reservoir rocks. Emphasis will be on the temporal and spatial distribution of alteration products in actual reservoirs and on theoretical models of heat, mass, and fluid flow.

To attend, contact J. R. Wood, COFRC, P.O. Box 446, La Habra, CA 90631; deadline is April 30. Include a brief description of topics to be contributed and the reason for wanting to attend. Convenors of the conference are Wood; Ian Hutcheon, Department of Geology, University of Calgary, Calgary, AB, Canada, T2N 1N4; and J. R. Boles, Department of Geology, UCSB, Santa Barbara, CA 93017.

National Water Conference

Representatives from the Academy of Natural Sciences, the American Water Works Association, and the Water Pollution Control Federation will consider how successful the United States has been in its approach to water pollution control and other questions relating to water quality and the Clean Water Act during the National Water Conference to be held in Philadelphia, Pa., January 26–27, 1982.

The purpose of the conference is to compile scientific information on what has been achieved by the Clean Water Act. 'This information can be of use to environmentally concerned people, industry, and lawmakers during their forthcoming deliberations on the future of the nation's water pollution control laws,' according to Ruth Patrick, chairman of the conference planning committee.

For additional information, contact James Wilson, Secretary, The National Water Conference, Academy of Natural Sciences, 19th and the Parkway, Philadelphia, PA 19103 (telephone: 215-299-1107).

Environmental Engineering Conference

A call for papers has been issued for the 1982 National Conference on Environmental Engineering, slated for July 14–16, 1982, at the Sheraton-Ritz Hotel in Minneapolis, Minn.

Papers on the following topics are especially requested: air quality, noise pollution, nuclear waste management, solid wastes, toxic and hazardous wastes, water pollution, and water supply and treatment.

Abstracts of approximately 500 words should include the title of paper; title, affiliation, and address of the author or authors (indicate which person will present the paper); the approximate date when the work was or will be completed; and, if applicable, if the work has been published or will be published elsewhere by July 1, 1982. Four copies of abstracts should be sent to Walter K. Johnson, Conference Chairman, Metropolitan Waste Control Commission, 350 Metro Square Building, St. Paul, MN 55101. Abstracts postmarked on or before December 18 will be accepted for review. Additional information may be obtained by calling Johnson (telephone: 612-222-8423).

The conference is sponsored by the American Society of Civil Engineers (Environmental Engineering Division) in cooperation with the University of Minnesota Department of Civil and Mineral Engineering, the Minnesota Pollution Control Agency, the Central States Water Pollution Control Association, and the Minnesota section of ASCE.

Travel Grants to IAG General Meeting

Deadline for Applications: January 1, 1982

AGU has applied to the National Science Foundation for a grant to assist the travel of individual U.S. scientists to the General Meeting of the International Association of Geodesy, to be held in Tokyo, Japan, May 7–20, 1982. Application forms for the grants are available from Member Programs Division, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009 (telephone 202-462-6903 or toll free 800-424-2488).

Princeton University Short Course

This course will cover fundamentals of the physics of flow through porous media, emphasizing problems arising in groundwater hydrology, oil reservoir engineering, contaminant transport, geothermal engineering, and soil physics. After developing the methodology for obtaining the balance laws of interest, the seminar will focus on numerical methods for solving the resulting partial differential equations. Case studies and hands-on computing experience will be included. The lectures will be given by Professor George F. Pinder.

For information please contact:
Dr George F. Pinder
Dept. of Civil Engineering (code 123)
Princeton University
Princeton, N.J. 08544
(609) 921-1123

Fundamental Concepts in Modelling Fluid Flow and Solute Transport in Porous Media

January 26 - 29, 1982

GAP

Geodesy and Gravity

1905 Artificial Satellite Techniques
INFLUENCE OF GRAVITY FIELD UNCERTAINTIES ON THE RESULTS FROM POGO AND MAGSAT GEOMAGNETIC SURVEYS
P. T. Taylor (Earth Survey Applications Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771), A. F. Schanzle, D. L. Jones, R. A. Langel and W. D. Kahn

Previous studies have shown several instances where airborne magnetic data, extrapolated to satellite altitude, differ from data obtained by the POGO and MAGSAT satellites. In an effort to explain this difference we have examined errors in the coefficients representing the Earth's gravitational field which could produce [illegible] positional variations and therefore would account for the observed differences. Our results indicate that while the magnitude of the orbital errors are in a range that could account for the amplitude of these observed variations, the frequency of the [illegible] orbital error is too large to explain the localized nature of the observed differences. Hence, uncertainty in the coefficients of the gravity model can not explain the observed phenomenon. In a separate, but related computation, large crustal gravity anomalies have also been examined and shown to be insufficient to produce the desired magnitude of orbital perturbation. (Gravity fields, magnetic anomalies, satellite data).
Geophys. Res. Lett., Paper [illegible]

1906 Artificial satellite techniques
SEA-STATE-RELATED ALTITUDE ERRORS IN THE SEASAT RADAR ALTIMETER
G. S. Hayne, D. W. Hancock, III (NASA Wallops Flight Center, Wallops Island, VA 23337)

For the work reported here, a six-parameter model waveform is least-squares fitted to ten-second averages of the data from the 63 waveform sampling gates in the Seasat radar altimeter. One of the fitted parameters is a time-origin parameter which provides a measure of the position of the actual mean radar waveform relative to the sampling gate set and thus provides a correction to the instrument's altitude measurement. For the data set analyzed, this correction appears to vary quadratically as a function of the significant waveheight (SWH). The result to date is that the correction Δh in centimeters, which should be added to the surface elevation measurements on the Seasat geophysical data record (GDR), is given by $\Delta h = 0.593\, S_G + 0.478\, S_G^2$ where S_G is the GDR value for SWH, in meters.

The discussion in this paper reviews waveform assumptions built into the Seasat on-board altimeter tracker and subsequent altitude data processing, and lists several additional important effects which were not included in that processing but which are incorporated into the Seasat waveform analysis reported here.
J. Geophys. Res., Green, Paper 1C1672

Hydrology

3130 Groundwater
OPTIMAL DYNAMIC MANAGEMENT OF GROUNDWATER POLLUTANT SOURCES
S.M. Gorelick (U S. Geological Survey, Menlo Park, California 94025) and I. Remson

The linear programing - superposition method is presented for managing multiple sources of groundwater pollution over time. The method uses any linear solute transport simulation model to generate a unit source - concentration response matrix that is incorporated into a management model. This series of constraints indicates local solute concentration histories that will result from any series of waste injection schedules. The linear program operates on the matrix to arrive at optimal disposal schedules. An example demonstrates application of the method to maximizing groundwater waste disposal while maintaining water quality of local water supplies within desired limits. Flow field variations associated with waste injection are ignored as an approximation. Parametric programing is shown to be an important tool in evaluating waste disposal tradeoffs at various injection sites over time. Mixed- integer programing permits restrictions to be placed upon the number of injection wells which may operate during given management periods. (Groundwater, pollution, optimization).
Water Resour. Res., Paper 1W1602

3160 Runoff and Streamflow
STOCHASTIC TRIGGER MODEL FOR THE FLOOD PEAKS. PART II. APPLICATION OF THE STOCHASTIC TRIGGER MODEL TO THE FLOOD PEAKS OF GOKSU-KARAHACILI
M.L. Kavvas (School of Civil Engineering, Purdue University, W. Lafayette, IN 47907)

In order to assess the suitability of the stochastic trigger process in modeling the flood peak occurrences in the time-discharge plane, the trigger process is applied to the flood peaks data of the Karahacili gaging station on the Goksu River of Turkey in each of the flood seasons which are defined in the paper. The flood peak process in each flood season is treated as a transient stochastic process which starts at the beginning of the season and ends at the end of the season. Consequently, the time-discharge nonhomogeneous trigger processes are used to model these seasonal flood peak processes.
Water Resour. Res., Paper 1W1618

3160 Runoff and Streamflow
STOCHASTIC TRIGGER MODEL FOR THE FLOOD PEAKS. PART I. DEVELOPMENT OF THE STOCHASTIC TRIGGER MODEL
M.L. Kavvas (School of Civil Engineering, Purdue University, W. Lafayette, IN 47907)

The flood peak occurrences at a river cross-section are treated as a two-dimensional stochastic counting process in the time-discharge plane. A two-dimensional nonhomogeneous stochastic trigger model for the flood peaks is developed in terms of its univariate, bivariate and multivariate probability generating functions. The first and the second theoretical moments and the theoretical one and two dimensional probability mass functions of the flood peak counts in the time-discharge plane are derived from the probability generating functions.
Water Resour. Res., Paper 1W1617

3160 Runoff and streamflow
COMBINING SITE-SPECIFIC AND REGIONAL INFORMATION: AN EMPIRICAL BAYES APPROACH
G. Kuczera (Department of Civil Engineering, Monash University, Clayton, Victoria, 3168, Australia)

Empirical Bayes theory, adapted to a hydrologic context, is used to develop procedures for inferring hydrologic quantities by combining site-specific and regional information. It "borrows strength" from "similar" basins to improve upon inference at a particular basin. The superpopulation is a key concept in the empirical Bayes approach. It is a probability distribution from which basin parameters are randomly assigned, a conceptualization closely related to regionalization models. It is inferred from observable regional data and expresses the degree of basin "similarity" in a region. This approach treats regionalized estimators as a special case and leads to procedures similar to James-Stein estimators. Empirical Bayes procedures can lead to substantial improvements in performance over site-specific procedures. However, for basins which are very different from the majority, site-specific procedures may perform better. The method of moments approach to inferring the superpopulation is considered in detail. Finally two examples in flood frequency analysis are presented to illustrate various facets of empirical Bayes procedures. (Inference, empirical Bayes, site and regional information).
Water Resour. Res., Paper 1W1574

Meteorology

3710 (Boundary Layer Structures and Processes)
LONG CLOUD OBSERVATIONS ON MARS AND IMPLICATIONS FOR BOUNDARY LAYER CHARACTERISTICS OVER SLOPES
B. Kahn, P. Gierasch (Center for Radiophysics and Space Research, Cornell University, Ithaca, New York, 14853)

Viking orbiter images of Mars show several instances of long continuous cloud formations on the slopes of Arsia and Pavonis Mons. We have searched all the images of the planet for occurrences of such formations. Only in the Tharsis region were long clouds unambiguously identified. We have measured the times and locations of occurrence, the wavelengths and when possible, the apparent velocity of motion of these clouds. We have also tabulated the wavelengths of patches of ripple clouds which are often found with the long formations. The long clouds are observed only in the early morning hours, suggesting that they are associated with drainage winds due to a cold planetary boundary layer. We develop simple mathematical models to examine various aspects of such boundary layer winds; these allow us to construct a complete and self-consistent explanation of all the observed features of the cloud formations. We use the results to characterize some physical properties of the Mars boundary layer. There is strong downslope flow in the boundary layer on the high slopes of both volcanos. In the saddle region between the peaks the flow slows and undergoes a hydraulic jump, producing the long clouds. Downstream of the jump, standing internal gravity waves can exist and are excited by flow over surface irregularities. Small variations in their observed wavelengths behind the jump may be attributed to variation in the flow speed and depth. Finally, we can account for the location of the jumps by the variation of relative strength of the boundary layer flows on the two volcanos. (Mars atmosphere, slope winds, boundary layers).
J. Geophys. Res., Blue, Paper 1A1567

3715 Chemical composition and chemical interactions
A TIME SERIES ANALYSIS OF UMKEHR DATA FROM AROSA
J. E. Penner, L. P. Golen, and R. W. Mensing (Lawrence Livermore Laboratory, Livermore, California 94550)

A time-series autoregressive-moving average model is fit to Umkehr data from Arosa for the time period March 1961 through December 1977. The ozone data in Umkehr levels 7, 8, and 9 are examined for trend commencing in January 1970. The summed data in levels 7, 8, and 9 are also examined. No significant trend is found at the 5% significance level.

Models are then refit for the entire sample period and detection thresholds are estimated for time periods after December 1977. The change in O_3 due to trend over the next ten years would need to be as large as 3.5%, 10.4%, and 23.3% in levels 7, 8, and 9, respectively, in order for tests based on these models to conclude there was a significant nonzero trend in the future. The trend in the summed data would need to be 5.3%. Thus we find that the data in Umkehr level 7 provide the smallest detection threshold for future detection of trend in upper level O_3. The detection thresholds found here are compared to detectability limits from total O_3 data.

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.
J. Geophys. Res., Green, Paper 1C1553

3735 Electrical Phenomena
CALCULATIONS OF LIGHTNING RETURN STROKE ELECTRIC AND MAGNETIC FIELDS ABOVE GROUND
M.J. Master (Department of Electrical Engineering, University of Florida, Gainesville, FL 32611, USA) M.A. Uman, Y.T. Lin, and R.B. Standler.

The first detailed calculations of lightning return stroke electric and magnetic fields above ground are presented. Waveforms are given for altitudes from 0 to 10 km and ranges from 20 m to 10 km. These waveforms are computed using the model of Lin et al. (1980) and a modification of that model in which the initial current peak decays with height above ground. Both the original and the modified models result in accurate prediction of measured ground-based fields. Return stroke field measurements above ground and close to the stroke, with which the calculations could be compared to test the validity of the model, have not yet been made. Salient aspects of the calculated fields are discussed, including their use in calibrating airborne field measurements from simultaneous ground and airborne data.
J. Geophys. Res., Green, Paper 1C1479

3735 Electrical Phenomena
THE DEPENDENCE OF SPACE CHARGE SPECTRA ON AITKEN NUCLEUS CONCENTRATIONS
R. V. Anderson (Code 4325, Naval Research Laboratory, Washington, DC 20375)

The theoretical behavior of atmospheric space charge in a field of turbulent mixing is reviewed, and the possible usefulness of space charge as a tracer of the turbulent process is introduced. It is shown that power spectra of space charge recordings could serve to identify whether the charge is primarily on large or small particles, and previous data are found to be insufficient to verify the validity of this prediction. An instrumental ensemble is described with which to record space charge fluctuations at temporary sites. A series of measurements is described in which the only significant background variation over a 24 hour period is in the Aitken nucleus density, and this variation exhibits a cyclic pattern attributable to morning rush hour activity. The spectral decay slopes of the corresponding space charge recordings are seen to vary inversely with the Aitken density in excellent agreement with the theoretical prediction.
J. Geophys. Res., Green, Paper 1C1571

3735 Electrical Phenomena
RESULTS OF AN INTERNATIONAL WORKSHOP ON ATMOSPHERIC ELECTRICAL MEASUREMENTS
J. M. Rosen (Department of Physics and Astronomy, University of Wyoming, Laramie, WY 82071)

An Atmospheric Electrical Measurements Workshop was conducted at the University of Wyoming in which balloon borne comparisons of ionization, conductivity, ion density, air-earth current and electric field measurements were made. After some deliberation there now appears to be relatively good agreement between the various experimental groups with a major exception being the ion density measurements. The source of this discrepancy is perhaps the poorly defined flow rate through some types of ion counters. Another important experimental result indicates that the direct measurements of air-earth current are almost exactly one half the value calculated from the total conductivity and electric field profiles. The values of the small ion mobility calculated from the workshop data suggest a relatively constant value to about 30 km, the maximum altitude of the soundings.
J. Geophys. Res., Green, Paper 1C1648

3736 Electrical phenomena
X-RAY ENHANCEMENTS DETECTED DURING THUNDERSTORM AND LIGHTNING ACTIVITIES
G. K. Parks (Geophysics AK-50, University of Washington, Seattle, Washington, 98195). B. H. Mauk, R. Spiger, and J. Chin

An X-ray detector has been flown on-board a NASA F-106 jet into thunderstorms. We have concluded that significant quantities of 3 to >12 keV X-rays are produced within thunderstorm clouds which support lightning discharge activity. It is inferred that the X-rays are the bremsstrahlung radiation emitted from energetic electrons which have been accelerated through run-away processes. It is suggested and supported that the structures responsible for the acceleration are strong double-layers which are supported by the very high current densities attributed to lightning discharges. (Lightning, X-rays, Run-away).
Geophys. Res. Lett., Paper 1L1641

3770 Particles and aerosols
ESTIMATION OF ATMOSPHERIC SEA SALT DRY DEPOSITION: WIND SPEED AND PARTICLE SIZE DEPENDENCE
R.L. McDonald, C.K. Unni, and R.A. Duce (Center for Atmospheric Chemistry Studies, Graduate School of Oceanography, University of Rhode Island, Kingston, Rhode Island 02881)

Cascade impactor and bulk filter samples of atmospheric sea salt were collected at wind speeds from 3.4 to 10 m/sec at coastal tower sites in the Florida Keys and Enewetak Atoll as part of the SEAREX (Sea Air Exchange) Program. Simultaneous dry deposition measurements were made to polyethylene plates. The samples were analyzed for Na as an indicator of sea salt. If the observed atmospheric sea salt particle mass distributions are corrected for the reduced collection efficiency of large particles, the observed dry deposition rates agree well with rates estimated from atmospheric sea salt particle concentrations and theoretical particle deposition velocities derived from gravitational settling velocities or from the equations of Slinn and Slinn (1980, 1981) for deposition to smooth, solid surfaces as well as natural water surfaces. The results emphasize the fact that even though large particles may represent only a small fraction of the total mass of sea salt over the ocean, they can dominate the dry deposition rates of the sea salt aerosol. (Sea salt, deposition, particle size, wind speed).
J. Geophys. Res., Green, Paper 1C1638

3799 General Meteorology (Atmospheric Ozone)
ANALYSIS OF TOTAL OZONE DATA FOR THE DETECTION OF RECENT TRENDS AND THE EFFECTS OF NUCLEAR TESTING DURING THE 1960's
G. C. Reinsel (Department of Statistics, University of Wisconsin, Madison, Wisconsin, 53706)

Time series modeling of monthly total ozone data is considered for the detection of changes in ozone due to the possible effects of nuclear weapons testing in the early 1960's and more recent effects of the release of chlorofluoromethanes (CFMs). Based on ozone data from a network of ground-based Dobson recording stations over the period 1958-1979, the results of this analysis are consistent with a maximum decrease in total ozone in the northern hemisphere of approximately 2 to 4.5% due to nuclear testing effects in the early 1960's. More importantly, our findings show little evidence of any significant trend in global total ozone occurring in the 1970's, with the global change during 1970-1979 estimated as $0.49 \pm 1.35\%$. (Total ozone, time series models, nuclear weapons testing effects, trends).
Geophys. Res. Lett., Paper 1L1627

Particles and Fields—Interplanetary Space

5340 Particles and Fields - Interplanetary Space (Shock Waves)
RADIO EVIDENCE FOR SHOCK ACCELERATION OF ELECTRONS IN THE SOLAR CORONA
H. V. Cane (NASA/Goddard Space Flight Center, Greenbelt, Maryland, 20771), R. G. Stone, J. Fainberg, R. T. Stewart, J. L. Steinberg and S. Hoang.

A new class of fast drift kilometer wavelength solar radio bursts has been observed with the ISEE-3 Radio Astronomy Experiment. These events are the long wavelength continuation of a category of meter wavelength bursts (the herringbone structure in type II bursts) which are considered to be caused by shock accelerated electrons. (Solar radio bursts, shock acceleration).
Geophys. Res. Lett., Paper 1L1691

5360 Solar wind interactions with moon and planets
THE STRUCTURE OF TITAN'S WAKE FROM PLASMA WAVE OBSERVATIONS
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During the Voyager 1 flyby of Saturn's moon Titan, the plasma wave instrument detected several types of plasma wave emissions. On the inbound leg a broad region of intense low frequency noise was detected on the side of Titan facing away from Saturn. This noise has characteristics similar to the electric field turbulence observed in the magnetosheath at Earth and the ionosheath at Venus and is believed to be generated by newly created ions which are being accelerated in the vicinity of Titan by the corotational electric field. During the pass through the induced magnetic tail of Titan, a series of upper hybrid resonance emissions were observed. The electron density profile inferred from these emissions shows three distinct peaks with densities of ~ 40 cm^{-3}, the first peak corresponding to the entry into the magnetic tail, the second peak corresponding to the neutral sheet crossing from the northern to the southern tail lobe, and the third somewhat smaller peak corresponding to the outbound exit from the tail. Large depressions in the magnetic field strength are observed coincident with each of the density peaks. These effects indicate that a dense plume of plasma is being carried downstream of Titan by the interaction with the rapidly rotating magnetosphere of Saturn. By equating the magnetic field pressure in the tail lobe to the plasma pressure in the neutral sheet, the temperature of the plasma is estimated to be about 8,600°K. This low temperature suggests that the plasma originates from the ionosphere of Titan, probably forming a plume of plasma with a U or H cross-section extending downstream from Titan. Within the tail lobes, a second type of low frequency electric field noise was observed with characteristics very similar to a type of noise called broadband electrostatic noise which is found in the Earth's magnetic tail. As in the case of the Earth, this noise is most intense near the outer boundary of the plasma sheet and is almost completely absent in the high density region near the neutral sheet.
J. Geophys. Res., Blue, Paper 1A1629

5380 Solar wind plasma
DECIMETER RADIO WAVES PROPAGATION IN THE TURBULENT PLASMA NEAR THE SUN USING VENERA-10 SPACECRAFT
M.A.Kolosov, O.I.Yakovlev, A.I.Efimov, V.I.Rogalsky, V.M.Razmanov, and V.K.Shtrykov (Institute of Radio Engineering and Electronics, the USSR Academy of Sciences, 103907, Marx Avenue 18, GSP-3, Moscow, USSR)

The radio occultation experiments conducted at 928 MHz with the Venera-10 spacecraft have indicated that during the solar cycle minimum the properties of the solar wind have specific character in the region of its acceleration. The intensity of the turbulence declines rapidly with the increasing heliocentric distance but at the distances between 12 and 20 solar radii R_o the turbulence has enhanced value. The spatial spectrum of the irregularities is close power law. The spectral index is close to the Kolmogorov value of 11/3 at the distances greater than 20 R_o and its value is significantly smaller (3,0±0,2) in the region of the enhanced turbulence. The inner scale of turbulence of the solar wind plasma is of the order of few kilometers at the distances between 6 and 10 R_o and one increases with the increasing radial distances. Typical values of the drift velocity of the irregularities are 30 to 40 km/s at the distances 4 R_o while at the distances greater than 10 R_o the velocity exceeds 400 km/s. (Solar wind, turbulence, corona, radio wave propagation).
Rad. Sci., Paper 1S1675

Particles and Fields—Ionosphere

5595 Auroras
PROBLEMS WITH THE $N_2^+ + O \to NO^+ + N$ REACTION IN AURORA
W. Swider (Air Force Geophysics Laboratory, Hanscom AFB, MA 01731), and R. S. Narcisi

An effective rate coefficient for $N_2^+ + O \to NO^+ + N$ which increases with altitude is deduced from an analysis of the auroral ion composition measured between [illegible] and 200 km over Poker Flat, Alaska on March [illegible], 1981. This result may be interpreted in terms of a rate coefficient with a positive temperature dependence, roughly [illegible] over a 300-1000K temperature range. Other interpretations are discussed, including the possibility that the N_2^+ ions are vibrationally excited.
Geophys. Res. Lett., Paper [illegible]

5530 High-Latitude Ionospheric Currents
RELATIONSHIPS BETWEEN THE BIRKELAND CURRENTS, IONOSPHERIC CURRENTS AND ELECTRIC FIELDS
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Calculations are made of the currents and electric fields in the ionosphere using a global model of the electron densities including conjugate coupling along field lines. Incoherent scatter and rocket measurements of high latitude electron densities have been used to derive realistic variations of the polar conductivities as a function of magnetic activity. The Birkeland currents have been specified in terms of three indices, the total current into and out of the hemisphere, the ratio of the magnitudes of the currents in the AM and PM sectors, R_{AP}, and R_{12}, the ratio of the magnitudes of the currents in region 1 and 2. The relationship between these parameters of the Birkeland current system and the auroral electrojet indices AE, AL, and AU is examined as well as the polar cap potential and the electric field at lower latitudes. The cusp currents have been modeled in relation to the interplanetary magnetic field and calculations are given of their effect on electric field and current patterns. The aim of this study is to produce a mathematical model of the currents, electric fields and energy inputs produced by field aligned currents that is consistent with, and specifiable in terms of, measured geophysical indices. (Birkeland currents, electric fields, cusp currents).
J. Geophys. Res., Blue, Paper 1A1676

5545 Ionospheric disturbances
SIMULTANEOUS ROCKET PROBE AND RADAR MEASUREMENTS OF EQUATORIAL SPREAD F—TRANSITIONAL AND SHORT WAVELENGTH RESULTS
M. C. Kelley (Cornell University, Ithaca, N.Y.) R. Pfaff, K. D. Baker, J. C. Ulwick, R. Livingston, C. Rino and R. Tsunoda

During the Plumex I rocket flight from Kwajalein Atoll, plasma density and electric field fluctuations were measured in situ, simultaneous with ground based radar backscatter measurements at 0.96 m and 0.36 m wavelengths. The intermediate wavelength (.1-10 km) in situ electron density measurements are described in a companion paper, while here we report the transitional and short wavelength results (1 - 100 m). These data include the first in situ equatorial spread F measurements of the electric field component of electrostatic fluctuations with wavelengths less than 1 m. At all altitudes above about 280 km, a repeatable form for the wavenumber spectrum was found for the electron density and electric field fluctuations at wavelengths less than about 100 m. The density spectrum varies approximately as k^{-5} and the electric field spectrum as k^{-3}. The steepness of the density spectrum corresponds to an absence of steep edges in the density waveform on the scale of 100 m and less. These two spectral forms are shown to be consistent with an explanation involving low frequency waves with finite wavenumbers parallel to the magnetic field ($k_\parallel$). Both theory and laboratory experiments show a power law density fluctuation spectrum for gradient driven drift waves with negative index in the range 4.5-6.0. Since such waves do have finite $k_\parallel$ and since sharp gradients exist in the spread F environment we conclude that at sufficiently high altitudes, drift waves act on the steep gradients caused by a primary longer wavelength instability to create the observed spectral form. At lower altitudes, a shallower spectral index was observed in the tens of meter range. This suggests an altitude threshold for the drift waves which is probably related to ion neutral collisions. The power law spectra show no marked change near $k_\perp r_i \approx 1$ where r_i is the ion gyro radius. Since low frequency drift waves are linearly stable for $k_\perp r_i \gtrsim 1$, it seems that a wave-wave interaction (cascade) operates to deposit energy in a range where waves are linearly damped. There is a slight suggestion of a spectral change (smaller negative index) for $k_\perp r_e \gtrsim .2$ which may be due to excitation of a lower hybrid drift wave and which may be related to the observed enhanced backscatter at wavelengths on the order of 1 m. A stability analysis shows that the plasma is near but on the stable side of the marginal stability boundary for the lower hybrid drift wave in the most intense region of backscatter. In regions devoid of drift waves, evidence is found for an exponential inner scale cutoff at a wavelength of 200 m.
J. Geophys. Res., Blue, Paper 1A1599

5563 Plasma motion (ionosphere, magnetosheath)
EVIDENCE FOR THE ACCELERATION OF IONOSPHERIC O^+ IN THE MAGNETOSHEATH OF VENUS
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Energetic ions ($E/q \geq 4$ kV) in the magnetosheath near Venus, in the vicinity of the planet's terminator plane, have been detected by the plasma analyser of the Pioneer-Venus Orbiter. These ions have energy per unit charge consistent with O^+, the most abundant ionospheric ion, moving at a speed somewhat slower than or comparable to the local magnetosheath speed. These ions are slowest and most intense at low altitudes. We interpret these observations as indicating that O^+ is picked up by the magnetosheath plasma and accelerated up to the ambient proton flow speed within one Venus radius of the surface of the planet, and subsequently convected away through the wake of the planet.
Geophys. Res. Lett., Paper 1L1624

5586 Wave propagation
APPLICATION OF WAVE FIELD RECONSTRUCTION OF VHF RADIO WAVE TO INVESTIGATE SINGLE, ISOLATED IONOSPHERIC IRREGULARITIES
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A wave field reconstruction method is presented and applied to VHF complex scintillation data obtained from the Wideband Satellite. The reconstructed wave fields at the altitude of the ionosphere are displayed in terms of amplitude and phase. They consist of different kinds of structures. In examples of Auroral zone data single, isolated diffraction centers can be clearly identified. But rapid fluctuating structures are encountered also, which are attributed to extended irregularities. In addition, the usefulness and limitations of the method are discussed.
Rad. Sci., Paper 1S1633

Physical Properties of Rocks

6110 Elasticity, fracture, and flow
ULTRASONIC STUDIES ON A BASALT MELT
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Compressional wave attenuation, Q_p^{-1}, and velocity, V_p, for an alkalic olivine basalt have been measured from 1250° to 1450°C and from 5 to 10 MHz by an ultrasonic interferometric technique. V_p shows no significant frequency or temperature dependence, and Q_p^{-1} increases with increasing frequency and decreasing temperature. For the conditions of this study, the melt can be modeled as a viscoelastic material with a single thermally activated structural relaxation mechanism having an activation energy of 2.2 eV and a relaxation time on the order of 1 ns. The data presented here fall in the region of the relaxation spectrum where the frequency, f, is much smaller than the relaxation frequency, and the absorption coefficient is proportional to f^2. Analysis of the data suggests that (1) compressional wave losses will be negligible in a basalt melt at seismic frequencies, and (2) the volume viscosity of basalt melt is comparable in magnitude to shear viscosity. (Rock melt, ultrasonic attenuation, velocity, viscosity).
Geophys. Res. Lett., Paper 1L1552

6110 Elasticity, Fracture, and Flow (Physical Properties of Rocks)
INJECTION AND THERMAL BREAKTHROUGH IN FRACTURED GEOTHERMAL RESERVOIRS
G. S. Bodvarsson and C. F. Tsang (Lawrence Berkeley Laboratory, Berkeley, California 94720)

In this study, the problem of cold water injection into a fractured geothermal reservoir is considered. During injection, the cold water will advance along the fractures, gradually extract heat from the adjacent rock matrix, and eventually arrive at the production wells. If the injected water has not fully heated up by then, detrimental effects on energy production from decreasing fluid enthalpies may result. This indicates the need to establish criteria for designing an injection/production scheme for fractured geothermal reservoirs.

The model considered in this work consists of an injection well fully penetrating a fractured geothermal reservoir containing equally spaced horizontal fractures. A constant-temperature liquid water is injected into the fractures and, with the rock matrix assumed to be impermeable, the effect of heat conduction on the advancement of the "cold" water along the fractures is observed. Key dimensionless parameters that describe the physical system are identified and type curves are generated. These are intended to be used in the design of injection/production systems, mainly for determining the appropriate locations and the flow rates of the injection wells. Also, temperature contour maps are given, and these can be used to estimate the amount of recoverable energy from the geothermal system, based on a given injection/production scheme.

Numerical studies are also made to investigate the importance of the assumptions in the analytical work and to extend the work to cases where the rock matrix is permeable. The results are intended to be used as a constraint on results calculated using the type curves.

Finally, two simple numerical examples using a hypothetical doublet and the Cerro Prieto geological model are given. In the doublet case, a reservoir with 2 to 5 fractures is considered and breakthrough times of 13 and 65 years respectively are calculated. Using typical injection rate and the Cerro Prieto geological model, our calculations indicate that the thermal front will have advanced only 240 m away from the injection well after 30 years of injection. It is furthermore illustrated that this estimate is independent of fractures in the reservoir. (Fractures, injection, geothermal)
[illegible]

Planetology

6510 Planetology
PHOTOCHEMISTRY OF SO_2 IN THE ATMOSPHERE OF IO AND IMPLICATIONS ON ATMOSPHERIC ESCAPE
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Photochemical models of Io's atmosphere are presented with the assumption that SO_2 is the major gas and that the SO_2 surface pressure is controlled by vapor-pressure equilibrium at the surface. Photolysis of SO_2 leads to efficient production of SO, O_2, S and O. Of these products, O and S are likely to be the dominant constituents in the upper atmosphere and the atmospheric escape is expected to be in atomic form. Nonthermal escape processes are necessary to populate the plasma torus. SO_2 surface-densities greater than 10^{11} cm^{-3} are needed on the dayside to supply the required amounts of S and O to maintain the torus. Surface chemistry presents an interesting possibility, namely the conversion of O to O_2 in which case O_2 will be the dominant constituent throughout the nightside and over the polar caps with a surface O_2 density of 10^{10} cm^{-3}.
J. Geophys. Res., Blue, Paper 1A1549

6599 Miscellaneous (Planetology)
VENUS NIGHTSIDE IONOSPHERIC HOLES: THE SIGNATURES OF PARALLEL ELECTRIC FIELD ACCELERATION REGIONS?
J. M. Grebowsky (Both at NASA/Goddard Space Flight Center, Greenbelt, Maryland, 20771), S. A. Curtis

Recent observations by the instruments onboard the Pioneer Venus spacecraft have revealed the existence of "holes" or regions of density depletion in the nightside Venus ionosphere (Brace et al., 1981). These holes are associated with regions of radial magnetic fields (Luhmann et al., 1981). The properties of the electrons within the core of these holes are suggestive of an acceleration process along the magnetic field lines as are the Venera 9 and 10 observations of energetic ions in the Venus tail. Given the observational information, we have constructed a theory which attributes these Venusian plasma depletions to the presence of parallel electric fields similar to those observed in the terrestrial auroral ionosphere. The resulting electric field accelerates electrons down the field lines producing heating of the depleted thermal electron population within the hole and production of ionization below the hole. Simultaneously ionospheric ions are accelerated outward toward the plasmasheet.
Geophys. Res. Lett., Paper 1L1633

6599 General
IGNIMBRITES OF AMAZONIS PLANITIA REGION OF MARS
David H. Scott and Kenneth L. Tanaka (U.S. Geological Survey, Flagstaff, AZ 86001)

A series of rock units resembling terrestrial ignimbrites in their large scale properties has been mapped in the Amazonis Planitia region of Mars. The postulated ignimbrites cover more than 2 million km^2 within a broad belt extending east-west along the highland-lowland boundary. They overlie parts of the aureole materials of Olympus Mons but are embayed and overlapped in places by lava plains of the lowlands. Stratigraphic relations between the ignimbrites and lava flows from Tharsis Montes volcanoes are not clearly defined but the younger ignimbrites probably postdate the lava flows. They form extensive, relatively flat sheets that have smooth to gently undulating surfaces very similar to ash-flow tuffs of the Pancake Range in central Nevada. The more resistant, possibly welded, layers have linear grooves and ridges that appear to be complimentary joint sets etched by the wind. Four major eruptive centers, some with probable vents, are localized where the ignimbrites are thickest. (Ignimbrites, Mars).
J. Geophys. Res., Red, Paper 1B1699